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ELECTRICITY — COMMUNICATIONS — SERVICE — SOUND

APRIL 1st, 1950

VOL. 5, NO. 2

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# RADIO and ELECTRONICS

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# SOMETHING NEW!

There recently became available to us a small and extremely sensitive relay. This was one of those things which just ask to have something new designed round them, so we took out our thinking caps, dusted them off, and came up with an idea for a receiver which would perhaps make a small stir in the radio control world if it came off!

Well, things never turn out exactly according to expectations, much less in line with one's fondest hopes, but nevertheless, we have produced a receiver which appears to have some merit, even if we do say it ourselves. A full description, including constructional details and photographs, will be ready for the May issue of this journal, but for those who are specially interested in remote control, it may be useful to give some advance details here.

The relay referred to above can be arranged to close at a current through its coils of either 75 or 150 microamps, according to the way the windings are connected. This being so, it was argued that the receiver should be able to be made using sub-miniature valves rather than standard miniatures, since the difficulty appeared to be, on initial examination, that of finding a tube that is easily enough cut off, rather than one which would pass enough current! With this as a starting point, a test circuit was built using the basic arrangement of Mr. L. H. Wright, whose control receiver has been described in these pages. At the outset, it was felt that one ought to be able to make a workable receiver with sub-miniature valves, which would need only 22.5 volts of H.T., and in this at least, we were not disappointed. Another major improvement that was visualized was that of cutting down to a bare minimum the space occupied by the receiver.

Of course, the idea behind all this is that of reducing size and weight, so that radio control can become a practical possibility for small models—in particular, small and light model aircraft. Current practice in Britain and America seems to be to use a comparatively large and heavy aeroplane, and these are costly in themselves, without considering the radio gear. The commercial equipment at present being sold in the United Kingdom for radio control weighs seventeen ounces or more, so that our objective was to produce a receiver that, complete with batteries and actuating mechanism, would weigh, if possible, less than half a pound. It seemed, then, that the combination of very sensitive relay and low H.T. voltage would go a long way towards reducing things still further. To cut a long story short, the receiver has been built, tested, and found satisfactory as regards reliability and range are concerned. Unfortunately, it weighs a little more than had originally been hoped. The receiver itself, complete with relay, but without batteries or actuator mechanism, weighs $4\frac{3}{4}$ ounces. Some of the other figures may also be of interest. It comprises three valves—a super-regenerative detector, an audio amplifier, and a relay tube. The total A battery drain is 75 ma., while the H.T. current is less than 400 microamps with the relay operated, and less than 300 with the relay open. The B battery voltage required is 22.5, and the set is capable of working throughout the useful life of a 22.5 volt dry battery.

It is too early to say yet whether we will manage to get the weights down to 8 oz. complete, if dry batteries are used, but in the light of some work done on very small accumulators, it seems not impossible that a B battery could be made for it weighing approximately $1\frac{1}{2}$ ounces. If a mechanical actuator of the escapement type is used, this would bring the 8 oz. mark for the complete control gear well within the bounds of possibility.

As to size, the receiver, with the relay built in, measures 3 in. x $1\frac{3}{4}$ in. x $1\frac{1}{4}$ in. From what we have gleaned of the design of model aircraft, it seems quite possible that a sailplane with a span of only 36 in. could carry this gear successfully. Should this prove to be so, this receiver will enable interested radio men to build a radio-controlled model with little or no previous experience of model-building, and at a cost of only a few shillings apart from that of the radio gear.

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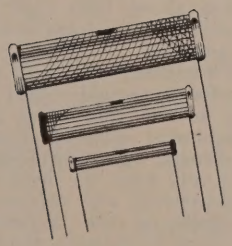

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# Some More About The Dynamic Nose Suppressor

**An article printed in our February 1950 issue described the manner in which the Scott Dynamic Noise Suppressor works, and gave his circuit for a simplified version, suitable for home use. It was not possible in a single article to go into quite as much detail as may have been desirable, and so the short article below has been prepared in order to say some of the things that were previously left unsaid.**

## INTRODUCTION

Since the desirability of decreasing the nuisance-value of the surface noise that appears on gramophone records is hardly in question, we can begin this article with a little discussion of the theoretical background on which the dynamic noise suppressor rests. This does not mean the theory of the actual circuit itself, but the theory of the ear, and the mechanism of hearing, because if the ear worked differently, the idea of the suppressor would be fundamentally unsound. Like most people in this country, we have not yet had an opportunity to hear a dynamic noise suppressor in action, and so have no means of expressing an opinion on its efficacy, other than on general theoretical grounds. However, these grounds are well established and sound, and there seems no doubt whatever that if the circuits can be assumed to work in the manner required by the theory, then the scheme must of necessity be successful. This again is not to say that any noise suppressor that may be built will be successful in all respects, because it is quite possible for design to outrun performance! But some opinions we have heard on the probable effectiveness of the suppressor seem to indicate that their holders do not fully understand the ideas behind the circuit.

## WHY IT IS POSSIBLE

One criticism that is often heard is that it is surely impossible to curtail the frequency response of the amplifier so severely during quiet passages without the ear noticing the change, and regarding it as an impairment of quality.

Now this question strikes right at the root of the matter. *It is because of a peculiarity of the ear that during soft passages the frequency response can be cut without any noticeable effect on the quality.* Furthermore, this same peculiarity of the ear comes into play at all times, and not just when we are listening to the sound from a loud-speaker. It is simply that *the frequency response of the ear is wider for loud sounds than for weak ones.* If you have not yourself noticed this fact, you might have noticed that when an amplifier is turned well up it sounds very well, but that when the level is reduced to a low figure, quite a large amount of the bass response, and also the high-frequency, response too, disappears. This is the main reason why the owners of good amplifiers like to "turn the wick up" when really listening for greatest enjoyment, or when demonstrating to a friend just how good the outfit is. It is the reason, too, behind the idea of having automatic bass boost, operated from the volume control shaft, which gives more boost the lower the volume control setting.

At present, however, we are considering how this undoubted fact affects the dynamic noise suppressor.

There is a graph, well known to acoustics engineers, which shows how the sensitivity of the ear varies with frequency. By "the ear," of course, is meant the "average ear" if such a thing may be considered to exist. In other words, most people's hearing conforms more or less to this curve. Anyone who may be interested enough to look it up, will find it on Page 88 of the Radiotron Designers' Handbook. On this graph there are several curves, each taken for one particular loudness level. However, the one we are interested in here is the lowest curve, labelled "Threshold of Audibility." This shows that for sounds of different frequencies to be just audible the sound energy required is vastly different for different frequencies. The least energy is required at about 1000 c/sec., which is the same thing as saying that the sensitivity of the ear is greatest at this frequency. As the frequency decreased, so the sensitivity of the ear falls off quite rapidly, until it is almost 60 db. less at 30 c/sec. than at 1000 c/sec. At higher frequencies, also, the sensitivity falls off, but more gradually, and not to the same total extent, and after an initial slight rise of about 6 db. between 1000 and 5000 c/sec.

In order to see how the response of the ear affects the sound of music, it is necessary to know something about the way in which the actual sound power output of an orchestra varies with frequency. For instance, there is no reason to suppose that just because it is possible for an orchestra to produce sounds that cover the range from 30 to 15,000 c/sec., it does so all the time! One can imagine what sort of noise it would make if it did! Because of this, several workers have gone to considerable trouble to measure as accurately as possible the relative power output of, say a symphony orchestra, at all frequencies within the audio range. Of course, the power distribution will not be constant for all orchestras, or for all pieces of music, but it has been possible to obtain a curve representing the average power output at different frequencies, for the normal type of symphony orchestra, and the average kind of music. All this sounds very approximate, and so it is, but some measurements are better than none, and results have shown that the ones referred to are reasonably well borne out in practice. As luck would have it, it has been found that the greatest sound power is generated in the middle frequency range, again round about 1000 c/sec., and that on the average, the power output drops considerably at both low and high frequencies.

When the results for the frequency response of the ear are compared with those for the sound output of an orchestra, it is found that several interesting points emerge. First of all (and this is most important from the listener's point of view) it is found that the full audible range of frequencies is heard only when the orchestra is playing loudly. (Note the absence of any reference so far to loud-speakers.) Secondly, if the orchestra is playing softly, or is heard from a distance, the range of frequencies heard becomes more and more restricted the softer the music becomes, until when it is just audible, and no more, the only frequencies that can be heard are a very restricted slice between approximately 500 and 3000 c/sec.

The foregoing are statements of fact, not merely suppositions with no basis of proof, so that it can definitely be taken as true that when the music is loud, we need the full frequency range to be reproduced, but when it is soft, the frequencies below and above the

points where the sound output curve of the orchestra falls to the same level as the curve for the threshold of audibility can be completely eliminated from the reproduction without the ear being any the wiser. This, then, is the fundamental basis on which the dynamic noise suppressor rests. If the noise on a record could be made to fluctuate in accordance with the loudness of the music, there would be no need for a dynamic suppressor at all, but unfortunately, this is not yet possible, and if it were, it would be possible to make noiseless records in any case.

What the noise suppressor sets out to do, therefore, is (a) to reduce the noise by restricting the frequency response at such times as the signal level is low, during which times a wide response is not needed, and (b) to widen the response (1) when the musical frequencies on the record require it, and (2) when the level is loud enough for the surface noise to be inaudible anyway. To do so in a completely effective manner depends not on the inventor of the *idea* of the dynamic suppression, but on the circuit designer, and such is the ingenuity put into circuit design these days that it is not surprising if very satisfactory practical units are turned out.

Neither the inventor, H. H. Scott, nor ourselves make any claims for the circuit printed in our previous article other than that it does perform the necessary circuit tricks to make some sort of dynamic noise suppression a reality.

In conclusion, we would be very pleased to hear from any of our readers who have built up the specimen circuit already published, so that some practical results from this interesting scheme can be passed on, preferably in the form of an article for publication.


# Beacon Technical Topics No. 22

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# A Wide-Band Amplifier For Oscilloscopes

## PART II: AN IMPROVED INPUT CIRCUIT AND A SUITABLE ATTENUATOR

Last month, in Part I of this article, a description was given of the main circuit for a two-stage, wide-band amplifier capable of deflecting a 5 in. oscilloscope tube. The design was discussed, and some of the uses to which such an amplifier can be put were described. Unfortunately, a few lines from the end of the article were omitted, so we will commence Part II by completing the unfinished sentence. This should have read: "Also, if careful measurements are made of the modulation patterns, it should be possible to estimate with fair accuracy the depth of modulation, as well as indicating whether much second harmonic distortion is present."

## AN IMPROVED INPUT CIRCUIT

Last month's article mentioned the use of a stepped, compensated attenuator in place of a volume control, for the purpose of keeping the frequency response the same at all settings of the control. The general scheme of the attenuator was described, but no full circuit of it was given. In order to assist those who may not feel disposed to work out the circuit values or the switch connections for themselves, it has been decided that it would be a good thing to give complete details here. In addition, it was felt advisable to outline the circuit of a very useful modification to the original circuit. This consists in adding a cathode follower valve ahead of the whole amplifier; in the first place, a cathode follower has a much higher input resistance and a much lower input capacity than an ordinary amplifier valve. This makes the extra tube a valuable addition to the original circuit. At the same time, the low-frequency response can be improved, because it now becomes possible to couple the cathode follower directly to the first valve in the amplifier proper. When this is done, it is still necessary to have a blocking condenser between the input terminal and the first stage (which is now a cathode follower), but because of the greatly increased input resistance, the normal-sized condenser gives a much better low-frequency response.

For those who may not have the original circuit of the wide-band amplifier available, we have reprinted it here, together with the circuit of the input attenuator and cathode follower input stage. This uses a further 6AC7, connected as a triode. With its high value of mutual conductance, this tube is very suitable as a cathode follower, and has a response that is flat out to at least 12 mc/sec. with the values used. It is thus impossible for the extra tube to affect adversely the high-frequency performance of the main circuit.

## DIRECT COUPLING BETWEEN THE FIRST AND SECOND STAGES

Referring to the main circuit diagram, it is seen that a positive voltage is fed from a voltage divider to the grids of the two 6AC7s. This, it was explained, is to help counteract the effect of the 1500-ohm cathode resistor. For the 6AC7, this value for two tubes would result in gross over-biasing if the grids were returned directly to earth. The plate current of the valves is 25 ma., with a further 5 ma. or so for the screens, and the whole 30 ma. flowing through the cathode resistor places the cathodes at a potential of 45 volts positive. In order that the valves should be biased correctly, it is necessary for the grids to be approximately 42 volts positive with respect to chassis, or 3 volts **negative** with respect to cathode. In the original circuit, this was done by the voltage divider of 100k. in series with the resistor R, R being chosen so that the current drawn by the stage is correct. The grid of the lower 6AC7 is effectively earthed as far as signal voltages are concerned by the large bypass condenser of 16 μf. A point that was not mentioned before was the connection of a 0.004 μf. condenser in parallel with the electrolytic. This has been done because the electrolytic condenser is more likely to act as an inductance at the higher frequencies than as a condenser. Should this be the case, the 0.004 mica condenser will act as an effective bypass at frequencies where the 16 μf. one is not working as a bypass at all.

One well-known and sometimes annoying feature of the cathode follower circuit, whatever valve type may be used, is that the cathode is found at a comparatively high potential above ground. In some cases, especially where the cathode load resistor is high in value, the voltage between cathode and ground is as much as 100 volts or more. Should this exceed the manufacturer's rating for the allowable voltage between heater and cathode, the insulation inside the valve is likely to break down and cause trouble. However, where the cathode load resistor is low in value, as here, not only is the rating not exceeded, but the voltage is made use of. In fact, the load resistor was chosen rather with an eye to realizing the desired D.C. cathode voltage than in order to suit the cathode follower circuit. It is possible to do this, because the circuit is particularly non-critical with respect to the actual load resistance, unless this is lower than, say, a couple of thousand ohms.

The cathode follower, then, replaces the voltage divider that was shown in the original circuit. Fig. 2 shows how the cathode follower may be added to the latter circuit. The 100k. decoupling resistor between the two 6AC7 grids is retained, as are the large and small bypass condensers, and the grid of the top valve is taken directly to the top of the 10k. resistor of the cathode-follower. It will be noted that in Fig. 2 we have shown the large grid bypass condenser as having a value of 4 μf., not 16, as in the original circuit. This is not an error, but has been done purposely. The 4 μf. condenser has not been specified as an electrolytic. It should, in fact, be a high-quality, oil-filled condenser, with very low leakage, as such things normally have. Contrary to popular supposition, 500-volt condensers of this capacity are available, and are not expensive, when it is considered that they will outlast the rest of the parts in a set or amplifier and cost little more than an electrolytic, which has an indeterminate amount of leakage and a comparatively short life. Its use, for instance, has enabled us to specify exactly the value of cathode load resistance required for the cathode-follower stage, in order to bias the first amplifier valves correctly.

In the main circuit, the input coupling condenser was shown as 0.25 μf., and this value has been retained at the input to the cathode-follower. A very slight amount of working out will show that the elimination of the capacity coupling between the cathode-follower and the amplifier, and the use o

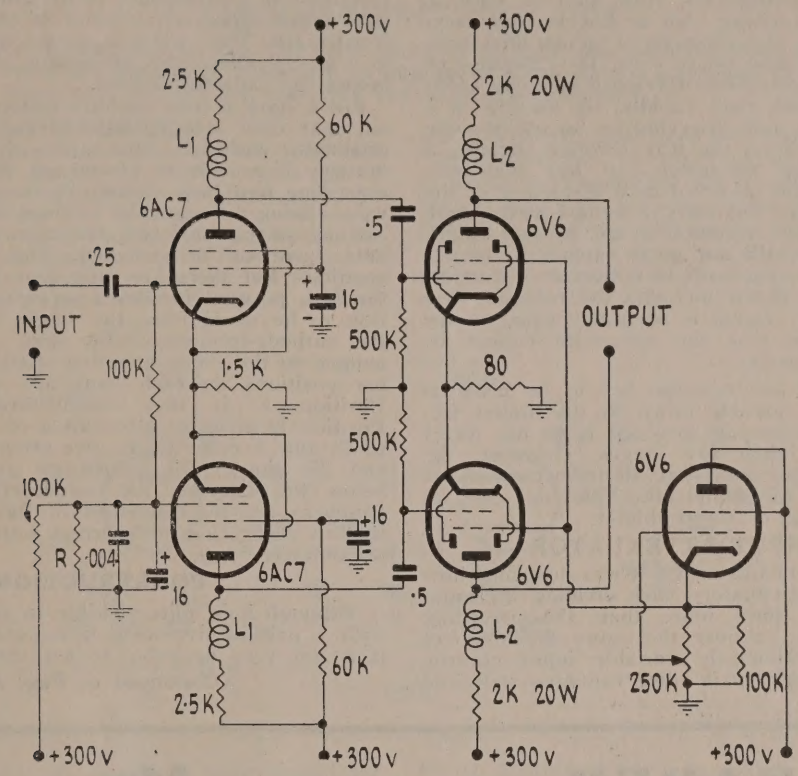
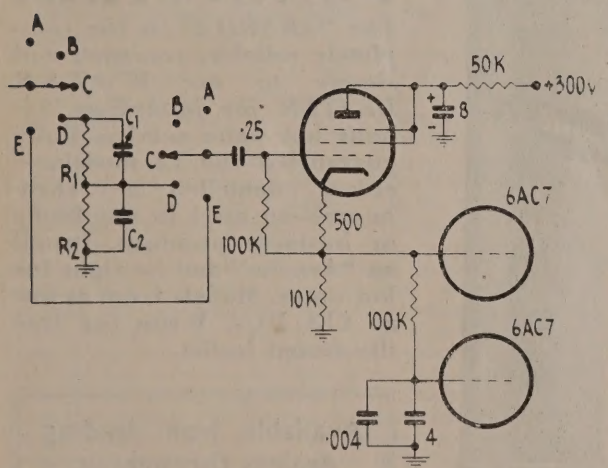



Fig. 1 above, is the original amplifier circuit, and thenew input arrangements are shown in Fig. 2, below.




VALUES FOR FIG. 2

| | SWITCH POSITION A | B | C | D |
|---|---|---|---|---|
| $R_1$ ..... | 1.5 meg. | 1.8 meg. | 2 meg. | 2 meg. |
| $R_2$ ..... | 0.5 meg. | 120k. | 30k. | 8k. |
| $C_1$ ..... | 3–30 pf. | 3–30 pf. | 3–30 pf. | 3–30 pf. |
| $C_2$ ..... | 15 $\mu\mu$f. | 100$\mu\mu$f. | 300 $\mu\mu$f. | 0.001$\mu$f. |

the same coupling condenser in front of the former. has improved the low-frequency response of the amplifier as a whole. If we take no account of the R-C coupling between the two amplifier stages, it can be reckoned that the response of the whole amplifier will be 3 db. down at the frequency where the 0.25 $\mu$f. input condenser has a reactance equal to the input resistance of the following stage. In the case of the main amplifier circuit, the input resistance of the 6AC7 amplifier stage is equal to 100k., the value of the grid leak.

Now, an 0.25 $\mu$f. condenser has a reactance of 100,000 ohms at a frequency of 6.3 c/sec., and so this gives some idea of the low-frequency performance of the input coupling circuit. If now we consider the cathode-follower circuit, we have the same-sized input condenser, but the input impedance of the valve is now about 2 megohms. (This follows from the theory of the cathode-follower circuit.) But the 0.25 $\mu$f. condenser has a reactance of 2 megs. at a frequency of only 0.32 c/sec. This, as most will agree, is pretty low! As far as response to audio frequencies is concerned, it is, but in an amplifier of this sort we are interested in a good deal more than audio range, at both ends of the scale.

As we mentioned earlier, a wide-band amplifier is often used for reproducing (visually, it is true) square-waves, and other irregular waveforms, of a

greater range of frequencies. And there is nothing like a square-wave, either high or low in frequency, for showing up the imperfections of an amplifier with regard to response and phase shift. It is because of this that methods have been developed whereby audio amplifiers are tested, very rapidly, by putting in a square-wave signal and observing on an oscilloscope what happens to it on the way through. Briefly, a phase shift at low frequencies of less than one degree can easily be observed as a distortion of the shape of what was originally a square-wave. And, good though the low response of the present amplifier may be, it is still not good enough to handle a 20 c/sec. square-wave without noticeable distortion. This, too, in spite of the fact that the response to a 20 c/sec. sine-wave signal is so nearly equal to the mid-band response that the difference cannot be observed on the 'scope!

Clearly, then, if the response has to be made as level as humanly possible down to the lowest frequencies, the only way to proceed is to use direct coupling between each two stages. However, the next best thing is to insert cathode-followers between every two stages of amplification, and not only at the very beginning of the amplifier.

## THE INPUT ATTENUATOR

In the first part of this article it was described how a series of fixed attenuators, each dividing the input voltage by four times more than the preceding section, could give almost the same flexibility of control as a continuously variable input control, without the latter's main disadvantage—undesired variations in the response of the amplifier. Here it is shown just how such a series of attenuators can be constructed. The circuit is shown in simplified form in Fig. 2, where the attenuator scheme is drawn before the cathode-follower.

For a start, it may simplify matters if it is pointed out that each step consists of an entirely separate attenuator network. One only of these has been drawn, so as not to clutter up the drawing. The remaining four have exactly the same form, only the values being different. All of them have one terminal earthed, so that only two, the input and output terminals, have to be switched. The switch has five positions, but there are only four attenuators, since the fifth position enables a straight-through connection to be made from the single input terminal to the cathode-follower. The two switch-banks are ganged to the same operating shaft, and corresponding positions on each bank are similarly labelled. Position E is the straight-through connection. Position D gives an attenuation of four times, while C, B, and A respectively give attenuations of 16, 64, and 256 times. The values are given in the table below the diagram. All condensers $C_1$ are Philips trimmers, and the condensers $C_2$ have been so chosen that in every case the correct setting for $C_1$ is approximately 5 $\mu\mu$f.

## CONSTRUCTION

Although it is quite possible to get wafer switches with a pair of five-position switches on one wafer, it is not very desirable to use them. Instead, it is

(Continued on Page 42.)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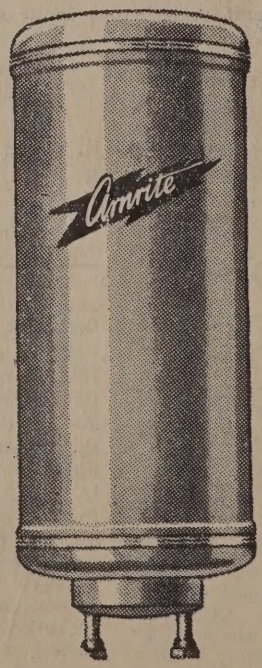


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# A Useful Gramophone Pre-Amplifier Circuit For Light-weight Pick-ups

**Some of the pre-amplifier circuits that have appeared recently have been fairly complex, without doing every job that might reasonably be expected of them. Here is a practical circuit which will fulfil many requirements but uses only one dual-purpose valve.**

## INTRODUCTION

Of recent years there have become available to gramophone enthusiasts a number of excellent pick-ups, of much higher quality than could be bought at any price before the war. These new pick-ups have very good characteristics, particularly with respect to frequency response and lack of annoying resonances. However, except for the crystal types, which have not made their appearance in this country to any extent, all of them are constant-velocity devices, and so require compensation for the drop in response of commercial recordings below the cross-over frequency, which lies in the region of 300 c/sec. Below this frequency, the records are made with a constant-amplitude characteristic, so that with a velocity-operated pick-up, the overall response is less by 6 db. for every octave below the cross-over frequency, unless bass compensation is applied. Thus, as most people are aware, it is usually necessary to have a pre-amplifier for the pick-up which will provide a little extra amplification, and at the same time compensate for the said 6 db. per octave recording drop. It is, of course, possible to insert a compensating network between the pick-up and the main amplifier, but in general, the latter will not have enough amplification to allow the pick-up to load the power stage fully if this is done. In the first place, these light-weight pick-ups have a comparatively low output (some of them, very low) and secondly, the compensating network produces a loss of signal voltage at all frequencies other than those being boosted, and causes the output to be smaller still. Hence the need for extra amplification when the pick-up is to be used with an existing amplifier, or with a radio set.

Several suitable circuits have appeared for performing the necessary functions about which we have been speaking, but most of them have their limitations. Of these, the most serious seems to be that the circuits do not provide for any effective bass boosting.

This may seem to be "this week's silly story," because such circuits give a bass boost approximately 6 db. per octave below the cross-over frequency so as to make the average record's response flat when played with the pick-up concerned. What we mean, however, is that by providing this amount of boost, all that *has* been done is to make the overall response flat. Thus, if for any purpose we wish to have more bass response than our now "flat" system has, we will need still more bass boost. If we had a pre-amplifier which would give a *minimum* bass boost of 6 db. per octave below 300 c/sec., and after that, an extra, controllable amount, we would not only be able to play records whose bass response after compensation in the ordinary way was sufficient, but in addition, we would be able to give further bass boost to records which might be somewhat lacking in bass, even after the compensation had taken place.

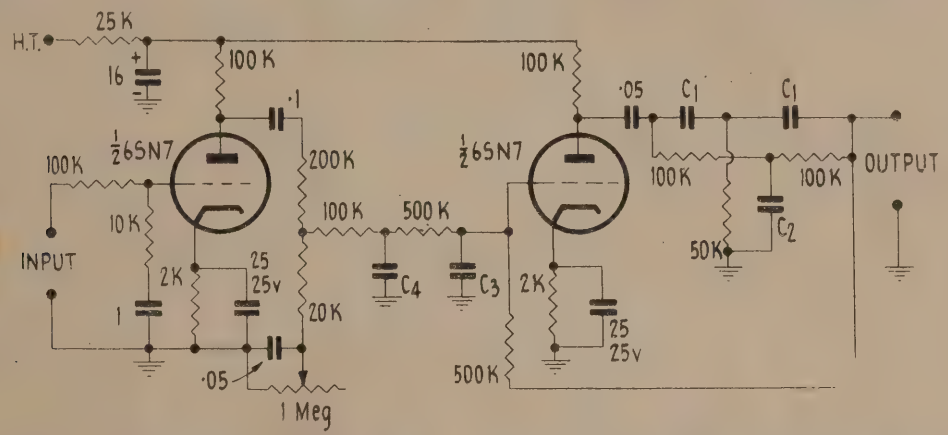


*Fig. 1*—Circuit of the pre-amplifier, giving fixed bass-boost, extra controllable bass boost, and a sharp cut-off low-pass filter at a frequency determined by $C_1$ to $C_4$. For suitable values, see below.

10,000 c/sec. cut-off
$C_1$, 100 $\mu\mu$f, $C_2$, 200 $\mu\mu$f. $C_3$, 50 $\mu\mu$f. $C_4$, 200 $\mu\mu$f.
7,000 c/sec.
$C_1$, 150 $\mu\mu$f. $C_2$, 300 $\mu\mu$f. $C_3$, 100 $\mu\mu$f. $C_4$, 300 $\mu\mu$f.
5,000 c/sec.
$C_1$, 200 $\mu\mu$f. $C_2$, 400 $\mu\mu$f. $C_3$, 250 $\mu\mu$f. $C_4$, 500 $\mu\mu$f.

This, then, is one of the things that the present circuit is able to do. We have provided in it, two bass boosting networks. One of them is fixed, and gives the official 6 db. per octave, which is enough for most records. Then there is a second network, of exactly the same kind as the first, but which is controllable, and can be made inoperative, or to have an extra 6 db. per octave of bass boost.

## ABOUT THE "HIGHS"

So far, the present discussion has centred round the low-frequency end of the audio scale, but we can now consider the latter to have been catered for, and give some thought to the top end.

Most often, it seems desirable to have as great a range of "flat" response as possible, and many of us have gone to great trouble to extend the useful high-frequency response of our gear. What is now about to be suggested will probably smack of heresy, therefore, to many readers. Nevertheless, we would ask that everyone should give us a hearing, and see whether there is not some sound sense in what is to be said.

Although, as has been said, we all strive at one time

or another for extended high-frequency response, the disconcerting fact emerges that there are times when it seems to be more of a disadvantage than a help in achieving realistic reproduction. It is sometimes hard to admit that this state of affairs is true, but unfortunately it is. We refer, of course, to the bugbear of surface noise, and sometimes high-frequency distortion, that is on the record itself, and over which we have no direct control, seeing we did not make the record!

There is, of course, a time-honoured method of dealing with this sort of thing, known as the "tone-control," and often called something else! We quality enthusiasts will generally have none of it, because to do so would be an admission of defeat, but this is by no means necessarily true. There are times when, owing to limitations in the very material which we have to reproduce, there is only one way to give a pleasant-sounding result. And this way is to limit the high-frequency response of the reproducer in some way. Another way out is to refuse to have anything to do with any but records which will sound their best when played with equipment having the widest possible range. Unfortunately, such records are few and far between, and few of us can afford, or have any desire, to scrap older recordings which are very satisfying musically, though not the best from the purely technical viewpoint.

If we admit, then, that some material cannot be played on wide-range equipment without undue noise or distortion, what can be done about it? The ordinary tone control is most unsatisfactory, since it causes a very marked loss in the higher frequencies at the same time as it partially eliminates the noise. A better scheme, and one which has been in use in commercial equipment for a long time, is to use a filter circuit which cuts the response off very sharply at a certain high frequency. This is quite different from the performance of the tone control kind of circuit, which has no sharply defined cut-off frequency, and starts to work at much lower frequencies than necessary. The filter circuit, on the other hand, gives virtually no attenuation to frequencies below the cut-off point, and almost no response at all above it. This kind of filter is called a low-pass filter, because it passes all frequencies *below* the cut-off point, and attenuates all frequencies above it. Hitherto, one of the difficulties associated with the use of such a filter has been that no circuits have existed whereby a simple arrangement of resistance and capacity has been able to give a sharp enough cut-off. Because of this, ordinary tone control circuits behave in the way indicated above, in that they attenuate frequences that we want to pass, and yet do not stop the frequencies we want to eliminate, effectively enough. In the past the only satisfactory way to make a low-pass filter with a nice sharp cut-off has been to use complicated circuits containing a number of inductances of accurately known value. These filters are difficult to design except to dyed-in-the-wool electrical engineers, and are costly to build and adjust. As a result, the only gear which used filters to any marked extent were such things as talkie equipment, telephone equipment, and other things whose performance was more important than their cost. Comparatively recently, however, circuits have been developed which enable the performance of L-C filters to be attained by means of simple R-C circuits in combination with feedback amplifier stages. This sounds quite fearsome, but in reality these circuits are quite easy to build and to get excellent performance from.

The pre-amplifier whose circuit is the subject of this story incorporates a low-pass filter of the kind just described, as well as the bass compensation circut, and so

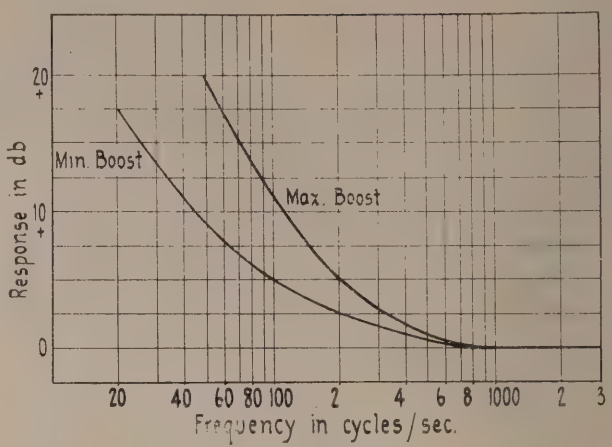


*Fig. 2*—Curves showing the performance of the low-frequency section of the pre-amplifier. "Min. Boost" is with the controllable section at zero, while "Max. Boost" is with the controllable section at maximum.

is capable of getting the best results out of the modern light-weight pick-ups that many have already purchased or are contemplating buying. Moreover, the whole thing employs only one double-purpose valve, in our case a 6SN7-GT, so that it cannot be reckoned at all expensive or complicated.

## PERFORMANCE OF THE CIRCUIT

Contrary to our usual procedure, the actual performance of the pre-amplifier unit will be described first, as this is its most importance characteristic. We have already described in general terms what the circuit does, and why these things need doing, so that now we will have a look at the actual performance curves, and see how well the thing does what we hope we have shown to be desirable.

Fig. 2 shows the measured response curves at low frequencies up to 3000 c/sec. The curve labelled "Minimum Boost" represents the response of the whole when the controllable boost is at zero. This amount of boost, as explained is just enough, according to theory, for the average recording, and in practice, too, the results on the majority of modern recordings are found to be quite satisfactory using this degree of boost. With the controllable boost at maximum, the other curve shows the response to be almost exactly twice the amount obtained from the fixed section. This should be more than enough to allow the bass to be brought up to a good level even on records that appear to be lacking in bass. At intermediate positions of the boost control, response intermediate between these two extremes will be obtained.

Fig. 3 shows the performance that may be obtained with various values in the low-pass filter circuit, which is the one associated with the second half of the 6SN7 in the circuit diagram, Fig. 1. The three curves labelled A, B, and C show the effects of three different sets of condensers in the low-pass filter circuit. These condensers are labelled $C_1$ to $C_4$ in the circuit, and upon their values, the cut-off frequency of the filter depends. There are several interesting points about these curves. First of all, it will be noted that the slope of all of them is very great, showing a very sharp cut-off. Moreover, the slope of the main part of all three is identical. The rate at which the cut-off occurs shows that frequencies above the cut-off in each case are very severely attenu-

ated, while those below the cut-off suffer no significant loss at all. In speaking of the cut-off frequency of a filter, it is usual to define this as the frequency where the attenuation is 3 db. An examination of the curves reveals cut-off frequencies for the three curves of 4000, 6000, and 8000 c/sec. respectively. Since the transition from the flat part of the curve to the steep part is not completely abrupt, some frequencies below cut-off *are* attenuated a little; for example, with the 4000 c/sec. cut-off, the response is up to its flat level at only 3000 c/sec. Above, it was stated that a sharp cut-off like this could not be obtained with ordinary R-C filter sections. Some idea of the rate of attenuation that could be had with ordinary tone control circuits, more elaborate than the usual ones used, can be got by turning the page upside down and examining the bass-boost curves of Fig. 2. Just as these give boosts of almost 6 and 12 db. per octave, respectively, so the corresponding top-cut circuits would only give attenuation at a similar rate. However, if the curves for the low-pass filter are examined, it will be found that the rate of attenuation is approximately 40 db. per octave. An octave, it may be explained, is a frequency ratio of 2 to 1. (The term is taken from music, of course, where it is known that notes one octave apart have vibration frequencies in this ratio.)

The next point of note about these curves is that quite close to the cut-off frequency, there is a point where maximum attenuation occurs. In each case, it is less than an octave away from the cut-off point. Then, the response rises a little, to a not very sharp peak, and falls again, after which we are no longer interested, because no further rise occurs, and it is impossible for frequencies higher than this to come through at all. For all practical purposes, it can be said that in an amplifier circuit of this sort, anything more than 20 db. attenuation represents complete inaudibility. Thus, when these filter circuits are used, all noise or distortion components occurring from a little above the cut-off frequency up, can be said to have been eliminated.

At the same time, which is also important, the frequencies below cut-off are substantially unaffected, and we are able to reap the benefit of all musical components up to the cut-off point. We will have a little more to say about the performance of the low-pass filter later, when we come to discuss its working.

## THE CIRCUIT IN DETAIL

Let us now take a more detailed view of the actual circuit. The fixed bass boost network starts the circuit off by being inserted in the grid circuit of the first valve. The network consists of a 100k. resistor, a 10k. resistor, and a 0.1 $\mu$f. condenser. (The marking showing this condenser as 1 $\mu$f., is an error.) It should first of all be noted that there does not appear to be an earth return for the first grid. However, this is completed by the pick-up winding itself, since the only kinds that will be used with this circuit are magnetic, of one sort or another, and all of them have a coil which provides the output voltage, and will also complete the grid circuit.

The manner in which the network functions is very readily explained. At very high audio frequencies, we can imagine the condenser to be a short circuit, because its reactance is so small that it can be neglected. The circuit then boils down to a voltage divider comprising the 100k. and 10k. resistors. Thus, at high frequencies, the output of the network is 1/11 of the input voltage. At very low frequencies, the reactance of the 0.1 $\mu$f. condenser is so great that it can be looked upon as an open circuit. This means that the voltage divider action no longer takes places, and that the full input voltage is applied to the valve. In this case, all the 100k. resistor does is to act as a grid stopper, with no effect on the input voltage at all. It is clear, then, that the maximum boost that the circuit can give is one of eleven times in terms of voltage amplification, or nearly 21 db. If the response curve in Fig. 2 were complete, it would show a flat portion at very low frequencies, and this would be 21 db. above the upper flat portion. However, in recorded music we are seldom interested in anything below 50 c/sec., so that for practical purposes the maximum boost is, say, 10 db. at 45 c/sec. Now, this kind of boost network can be very easily designed without any but the slightest bit of arithmetic, because the resistors determine

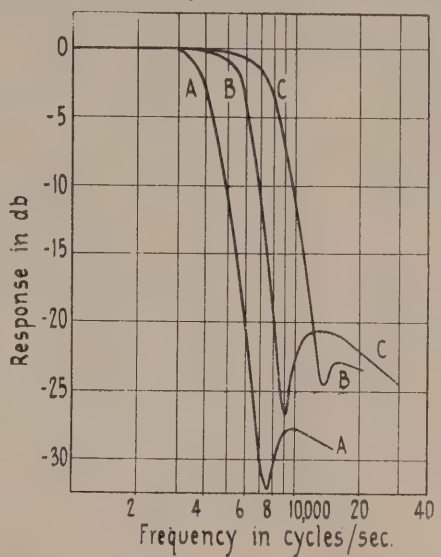


*Fig. 3*—Curves showing the performance of the low-pass filter with the three sets of values given in Fig. 1's caption. Please see the text for explanation of these curves.

the theoretical maximum boost, in the manner explained, and if more than approximately 6 db. per octave is wanted, this can be got by decreasing the value of the lower resistor relative to the upper one. With the resistor values fixed, the size of the condenser is the only thing that remains to be decided. Just as the resistor values fix the maximum theoretical boost, so do they determine the rate of boost that takes place over the almost linear central portion of the curve between the flat portions. All that the size of the condensers does is to determine *at what frequency* the boost starts to become effective. As before, it is usual to call the starting frequency the one at which the response is *up* by 3 db. compared with the upper flat portion. In the case illustrated, this frequency is approximately 150 c/sec. If the condenser value were halved, then the 3 db. point would be at twice the frequency. For those who like working things out, it may be stated that the 3 db. point comes accurately at the frequency where the reactance of the condenser is equal to the value of the lower resistor.

It will have been noticed by many readers that the so-called boost network is not a boost network at all. In other words it does not actively raise the response at any frequency. If it did, we would have the novel spectacle of an arrangement of resistors and condensers producing amplification! The network works by giving us a definite and predictable amount of attenuation. At high frequencies, this is fixed, as shown by the flat part

of the response curve. At lower ones, the loss decreases, until at zero frequency, there is no loss at all.

Now, if our pick-up has an output of, say, 0.33 volts, then only one-eleventh of this, or 0.03 volts will appear at the grid of the tube. This is numerical proof of the need for extra amplification after the compensating network has been inserted. One half of a 6SN7, used as a resistance-coupled amplifier with a 100k. plate load resistor, gives a gain of approximately 14 times, so that the tube gain makes up for the loss in the first network, with a little to spare. Our imaginary pick-up with an output of 0.33 volts would thus give a voltage of 0.42 at the plate of the first section of the 6SN7.

## THE LOW-PASS FILTER CIRCUIT

The rest of the circuit comprises (*a*) the second compensating network, and (*b*) the low-pass filter circuit. The first of these is another C-R circuit exactly similar in form to the first one. This time, however, it consists of a 200k., and a 20k. resistor, together with a 0.05 $\mu$f. condenser. These values give exactly the same frequency characteristic as those of the first network, but have a higher total resistance, so that the shunting on the plate circuit of the valve will be lower. At the junction of the 200k. and the 20k. resistors, the output voltage is picked off for applying to the next amplifier stage. This looks a little complicated at first sight, but it is quite easily explained in stages. In the first place we can ignore the 100k. and 500k. resistors, together with $C_4$ and $C_5$, and regard the 500k. resistor from the grid to the plate circuit as being disconnected at the latter end and earthed, becoming the grid leak for the stage. We are then left with the valve, and the output network.. The latter comprises $C_1$ (two of these), $C_2$, and the three resistors, two of 100k. and a third of 50k. This arrangement is called a "parallel T" network. It consists of two T-shaped networks in parallel. One of them is made up of the condensers $C_1$, together with the 50k. resistor, and the other consists of the two 100k. resistors and $C_2$. The vertical branch of each T is earthed, while one side becomes the input terminal, and the other, the output terminal. It will be seen that the horizontal arms of one T are the 100k. resistors, while the vertical arm of the other is 50k., or half this value. Similarly, the horizontal arms of the other T are equal condensers, while the vertical arm of the other is also a condenser, of twice the value of $C_1$. It should be noted that only the input and output terminals of the two networks are paralleled, and that the vertical arms are not connected directly at the junctions of the T's.

Now parallel-T networks of this kind behave in a way very similar to a tuned circuit. In this case, the similarity is to a series-tuned circuit, because there is a sharp dip in the response at the "resonance" frequency. This dip looks like the response curve of a very high-Q tuned circuit of the ordinary kind, and this is the basis of the filter. In the circuit, the output of the parallel-T network is connected back to the grid of the valve, so that at frequencies far removed from the "resonant" frequency of the network, the valve plus the feedback network has a gain of only about twice, instead of the 14 or so that the valve has without feedback. At the resonant frequency of the network, however, there is no feedback, but since the attenuation of the network is very great at this frequency, the gain does not become apparent, and the sharp dip is still there. But at fre-


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| Record Pressure | 20 grammes |
| Length of Arm | 12 inches |
| Arm Resonance | 25 cycles |
| Tracking Error | 2 degrees |
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quencies in the neighbourhood of the resonant frequency, there is some output from the network, and also the feedback is changed in phase so that it is no longer fully negative, and the circuit gain is intermediate between 14 (no feedback) and 2 (full feedback). This extra gain lifts the response level more closely towards the "flat" level that occurs away from the network resonant frequency. The nett effect is that the resonant dip becomes much more pronounced, and the sides steeper. Unfortunately, we do not want simply a dip in the audio response curve, but we do need the sharp drop, then to be followed by no rise at all, if this can be accomplished. It is not quite possible to do this, as the final curves show, but something very close to it is achieved, good enough for all practical purposes.

It is here that the condensers $C_3$ and $C_4$ come in. The first of these is part of the feedback network, and serves to unbalance the feedback, in such a way that at frequencies below the dip, the amplifier stage is a little regenerative, while above the dip frequency, extra degeneration is provided, which prevents the response from coming back to the original flat level. Unfortunately, this causes a slight rise of response to occur just before the cut-off frequency. This rise could be troublesome, and so the condenser $C_4$ is inserted in the circuit. $C_4$ is outside the feedback network, and adds to the attenuation of the parallel-T circuit. Its value is so chosen that it prevents the aforementioned rise from occurring, while at higher frequencies, it gives extra attenuation, and helps the network.

## VALUES IN THE PARALLEL-T NETWORK

By choosing the appropriate values for the five condensers in the filter circuit, the cut-off frequency can be made anything we choose. The effects of three sets of values are illustrated in Fig. 3, and these values are stated in the caption to Fig. 1.

The application of this circuit to audio amplifiers was suggested in the *Wireless World* recently by D. T. N. Williamson, of Williamson Amplifier fame, in an article in which he was describing appropriate pre-amplifier circuits for use in conjunction with the amplifier that now bears his name. In his list of values, he specified quite close tolerances for some of the condensers in the network. However, here it is not easy to come by 1 per cent. condensers, and most of us will have to put up with standard 20 per cent. tolerance ones. Because of this, it should be pointed out that the performance for the filter described by Williamson himself is not likely to be realized. As an indication of what to expect, our test circuits, from which the curves of Fig. 3 were drawn, were made up without any attempt to choose accurate condensers, just using nominal 100 $\mu\mu$f. mica condensers, and other values. It is because of this that curves A. B., and C in Fig. 3 do not all drop to the same low level, and it also explains why C rises higher than A and B do, above cut-off.

The most important result of not using very accurate values is that the cut-off frequencies do not come where calculation says they should. To give an idea of the magnitude of this effect, we can compare the actual cut-off frequency, obtained by us without using 1 per cent. condensers, and the calculated frequency, which is accurate when accurate condensers are used. The cut-off frequencies obtained by Williamson with the values given in the caption to Fig. 3 were 5, 7, and 10,000 c/sec. The ones actually obtained with ordinary condensers were 4, 6, and 8,000 c/sec. Thus, if accurate condensers are not procurable, it will be necessary to take the nominal cut-off frequencies with some reserve, and if possible, to


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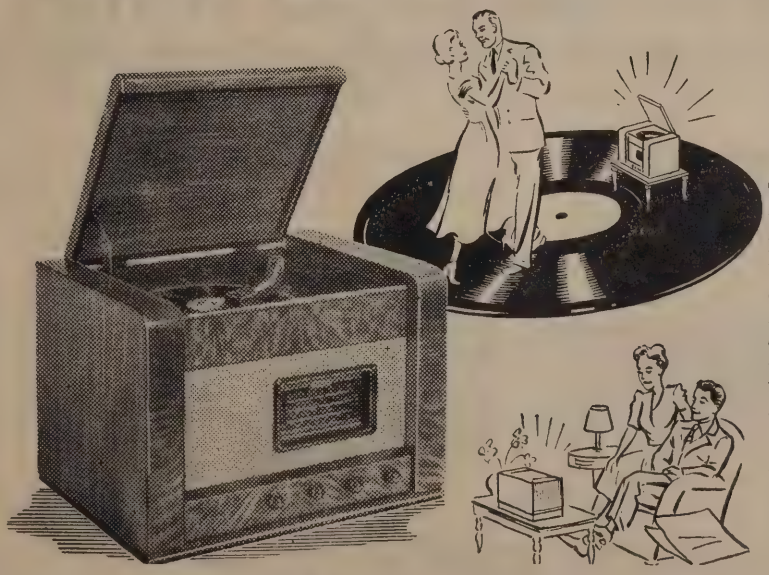

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measure the frequency for 3 db. drop in response to see if it is close enough to what is wanted. For those who have facilities for choosing more exact values, it is of interest to know that condensers $C_1$ should be within 1 per cent, of the nominal value, as should $C_2$. $C_3$ can be within 5 per cent., as can $C_4$. If these tolerances are used, there should be no need to measure the cut-off frequency, as it will be obtained accurately enough.

### SWITCHING

Most users of the above circuit will want to have at least two different cut-off frequencies. If so, a little switching has to be undertaken. A five-pole switch will be needed for this, since five condensers have to be switched, but this can easily be made up from ordinary wave-change switch wafers, three of which would be needed, each with as many positions as may be desired. If it is desired to have a position where no filtering is in use, it is only necessary to open-circuit the condensers in which case the response will be as wide as the amplifier can give. Any firm which specializes in making up wafer switches would be pleased to supply such a switch, with as many positions as might be desired. We did not draw the circuit diagram so as to include switching, in the interests of simplicity, because the switched version looks a lot more complicated than it really is.

### POWER SUPPLY

If the pre-amplifier is built into the main amplifier chassis, the power can be derived from the main power supply. The decoupling filter shown on the circuit diagram should on no account be omitted. If the pre-amplifier is built as a separate unit, it can have its own power supply, which can be made from a small 150v.-a-side instrument transformer, and a 6X5-GT rectifier. Smoothing can be done by a pair of 16 $\mu$f. electrolytics and a 20k. resistor, and in this case, the decoupling filter could be omitted.


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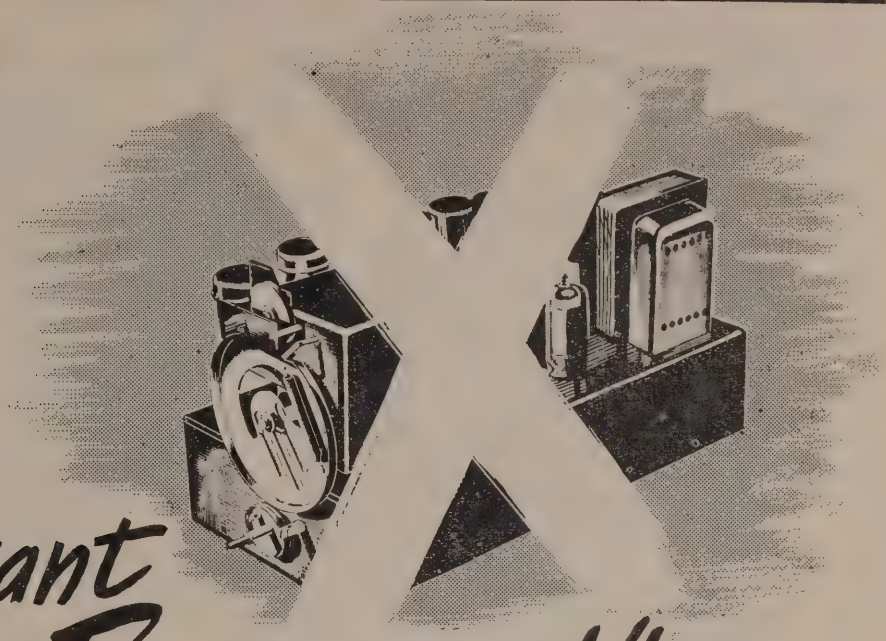

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# The *Radio and Electronics* Abstract Service

AERIALS AND TRANSMISSION LINES:

The design of low-pass filters which have many uses, but are specially valuable for the transmission line for filtering harmonics likely to interfere with T.V.

—*Wireless Engineer* (Eng.) December, 1949, p. 18.

The installation of a practical 75-metre mobile aerial—a base-loaded whip suitable for automobiles, with a simple mathematical explanation for adjustment.

—*QST* (U.S.A.) December, 1949, p. 25.

AUDIO EQUIPMENT AND DESIGN:

The duplicating of magnetic tape by contact printing is possible. The recorded master tape and the tape to be printed are run through controlled alternating field at high speeds with the magnetic surfaces in direct contact.

—*Electronics* (U.S.A.), December, 1949, p. 78.

A study of methods of reproduction of sounds below 50 cycles. The difficulties of reproduction at these low frequencies are referred to, with the technique of realistic base production.

—*Audio Engineering* (U.S.A.), December, 1949, p. 16.

CIRCUITS AND CIRCUIT ELEMENTS:

Frequency control for industrial oscillators such as those used for H.F. heating. A pulse controlled frequency stabilizing servo-mechanism for dielectric heating and diathermy equipment holds a self-excited power oscillator close to a crystal standard.

—*Electronics* (U.S.A.), December, 1949, p. 84.

The basic circuits for reactance tube modulation of phase shift oscillators are described. The design of suitable phase shift oscillators for frequencies from audio right through to the ultra-high-frequencies is discussed and the value of the apparatus.

—*The Bell System Technical Journal* (U.S.A.), October, 1949, p. 601.

The cathode follower as an audio power amplifier. Some examples of its use are given with advantages and circuitry.

—*Audio Engineering* (U.S.A.), December, 1949, p. 14.

ELECTRONIC DEVICES:

The control of a slide projector such as used by lecturers is effected by supersonic signals from a Galton whistle actuated by a bulb carried by the lecturer. An interesting practical device.

—*Electronics* (U.S.A.), December, 1949, p. 96.

A tone source for tuning musical instruments is described. The instrument produces a continuous tone with adjustable tone intensity, frequency, and timbre. It is especially useful for orchestral tuning.

—*Electronics* (U.S.A.), December, 1949, p. 164.

The Hammond spinnet. This is a simplified type of Hammond organ for home use.

*Electronic Engineering* (Eng.), December, 1949, p. 461.

Experiments with ultrasonic devices for assisting the blind. A description of efforts to produce a portable ultrasonic radar apparatus with interesting possibilities.

—*Electronic Engineering* (Eng.), December, 1949, p. 461.

MATERIALS AND SUBSIDIARY TECHNIQUES:

The synthesis of quartz crystals—a project speeded up by war needs involving the growth of crystals in solution.

*Electronic Engineering* (Eng.) January, 1950, p. 18.

A survey is given of various low-distortion valve constructions. Two new types are described by means of which the second harmonic of a single-stage Class A pentode amplifier can be considerably reduced. The new valves have a characteristic practically linear near the operating point.

—*Wireless Engineer* (Eng.), December, 1949, p. 385.

MATHEMATICS:

A description of, and mathematical analysis of phase-shift oscillators in widespread use in audio frequency work which depend upon exact reversal of phase between anode and grid.

—*Wireless Engineer* (Eng.), December, 1949, p. 391.

Graphical statistical methods. Properly used the methods provide the beginner with powerful statistical tools for the examination of data.

—*Wireless Engineer* (Eng.), December, 1949, p. 400.

An analogue computator for the solution of linear simultaneous equations which frequently occur in science and engineering. The computer saves laborious work in the solution of these equations.

—Proceedings of the I.R.E. (U.S.A.), December, 1949, p. 1467.

A simple reactance chart is supplied for filter design problems and should be most useful for those dealing with such.

—*Audio Engineering* (U.S.A.), December, 1949, p. 12.

Nomographs are given which are useful for the conversion of various units used in transmission line calculations. These are frequently expressed in various terms which may be confusing and involves considerable calculations. The nomographs facilitate conversion.

—*Communications* (U.S.A.), October, 1949, p. 24.

Determining of internal impedance. A graphic method is given for the calculation of impedances based on Thevenin's theorem.

—*Communications* (U.S.A.), October, 1949, p. 8.

MEASUREMENTS AND TEST GEAR:

The construction of an inexpensive valve voltmeter is described which is of simple peak-reading type with full-scale deflection scales of 1 to 250 volts. Steady voltages to 250 volts may also be measured.

—*Electronic Engineering* (Eng.), January, 1950, p. 9.

RECEPTION AND RECEIVERS:

A sky-wave F.M. receiver. Multi-path reception generally considered more troublesome for F.M. than A.M. A receiver capable of such reception is described. Tests indicate that transatlantic F.M. broadcasting is possible with 150 k.c. bandwidth.

—*Electronics* (U.S.A.), December, 1949, p. 96.

TELEVISION:

An experimental large-screen television projector using a high-voltage cathode ray tube is discussed. The modulation circuits, the projecting system and the directive projecting screen are described in detail.

—Proceedings of the I.R.E. (U.S.A.), December, 1949, p. 146.

An indication of new directions in colour television. The search for a colour system to fit the 6 m.c. channel of the black and white service has led to the field-sequential, line sequential and dot-sequential methods of transmission. The systems are described and compared.

—*Electronics* (U.S.A.), December, 1949, p. 66.

Dot systems of colour televison are described. Recent advances involve the application of new sampling and multiplexing techniques which are specially useful for colour television.

—*Electronics* (U.S.A.), December, p. 88.

MISCELLANEOUS:

Birth centenary of Ambrose Fleming. Historical notes of interest on the life and work of the inventor of the thermionic valve.

—*Electronic Engineer* (Eng.), January, 1950, p. 24.

The Standards Committeee appointed by the I.R.E. has defined nomenclature and terms in relations to (1) Radio aids to navigation; (2) Railroad and vehicular communications, methods of testing, requirements and characteristics of testing apparatus, and test procedures; (3) Tests for effects of mistuning and downward modulation; (4) Standards of piezo-electric crystals.

—Proceedings of the I.R.E. (U.S.A.), December, 1949, p. 1364.

A most interesting and comprehensive study of the theory of secrecy systems—methods of constructing cryptograms—the mathematical structure—some examples of secrecy systems—theoretical secrecy—practical working systems.

—*Bell System Telephone Journal* (U.S.A.), Oct., 1949, p. 656.

Chemical analysis of X-ray photometry. This method permits determination of the concentration of one element in mixtures or compounds.

—*Electronics* (U.S.A.), December, 1949, p. 87.

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Input Conditions: Resistance greater than 1 megohm at 1 mc/s. Capacitance approximately 7 mmf.

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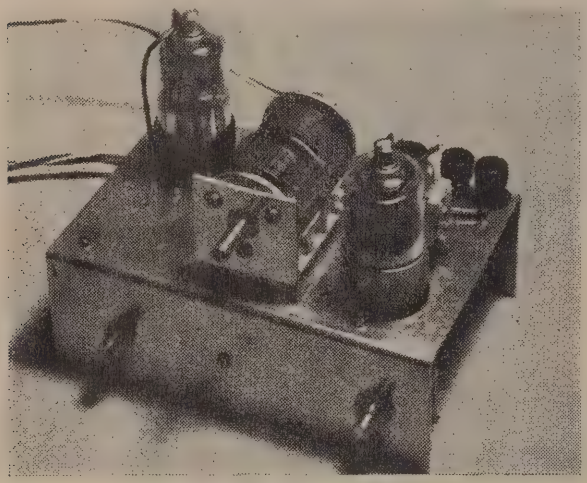
# A PRACTICAL BEGINNERS' COURSE

## PART 40: CONTINUING THE TWO-VALVE BATTERY SET FOR SPEAKER WORKING

In this set we have examples of two different kinds of audio amplifier. These are known as *voltage* amplifiers, and *power* amplifiers respectively. The distinction is one which the beginner to radio should have clearly in his mind, because this is a very common classification of amplifiers, which is constantly used in radio books.

Strictly speaking, *all* amplifiers are power amplifiers, because they give a greater signal power at their output terminal than is supplied to their grid. The classification is not a bad one, for all that, because it describes the *use* of the two classes reasonably accurately. That is to say, a voltage amplifier is one whose purpose in life is to increase the voltage of the signal. With a voltage amplifier, we are not interested in whether it gives a large or

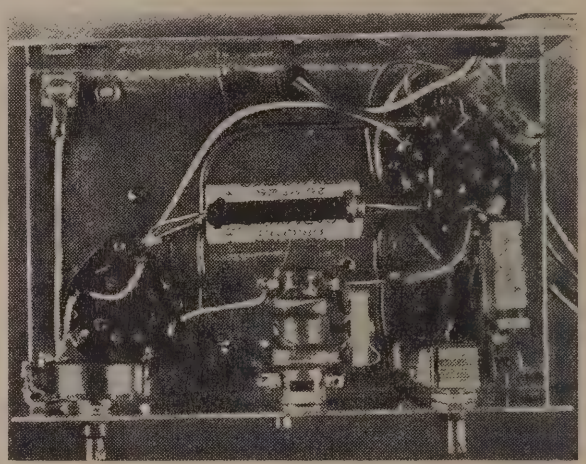


small power output as long as it increases the voltage of the signal, as defined. A power amplifier, however, has the purpose of increasing the power of the signal by a large amount, because it takes *power* to feed a speaker, or other device that may be connected to the output of the amplifier. This question of power is one which we have not yet dealt with, so we will have to say a few words about electrical power too.

### ELECTRICAL POWER

Now as we saw a long time ago, an electric current consists of a movement of electrons in a circuit. The number of electrons that pass a given point in one second could be (and actually is) a measure of the size of the current that flows. Now if everything else remains the same, *i.e.*, we still have the same circuit, but by some means or other we increase the current, through it, we increase the *power* used up in the circuit.

These electrons may be the ones flowing through the coils of an electric motor, in which case the increase of current makes the motor turn faster. This requires power to do, because the motor is now exerting more power, and this cannot be got for nothing. It must have come from the electric current. This shows in an elementary way that the *power* in a circuit, or in other words the amount of work that is done in a certain time, depends for one thing on the current flowing. However, the power also depends on the voltage applied to the circuit, because, in our imaginary motor, if we increase the voltage applied to it, this causes the current to increase, and the motor to turn faster, and to generate more mechanical power. The electrical power in a circuit therefore depends on the voltage, as well as on the current. Since one depends on the other in most circuits, the electrical power exerted by the electrons in a circuit depends on the *product* of voltage and current. Electrical power is measured in watts, just as mechanical power is measured in horse-power. The number of watts used up in a circuit is equal to the *voltage multiplied by the current.* Or, expressed in symbols, $W = I.E$ where W is the power in watts, I is the current in amperes, and E is the potential in volts of the source of current. Now, from this simple formula, we can see that if we



want a certain amount of electrical power, say 10 watts, for example, we can have this in an unlimited number of 1 amp. is causing a power of 10 watts to be consumed in the circuit, and 5 volts at a current of 2 amps, is still gives us a power of 10 watts. Similarly, 100 volts, causing a current of 0.1 amp, or 100 ma., or 1 volt making a current of 10 amps. In all these cases the power is the same. What, then, can cause such different voltages to generate different currents and all consume the same power? The answer to this one is simply the circuit itself. All these different cases represent circuits of different resistance. For example, in the case of the 10 volts and 1 amp, the resistance of the circuit must have been 10 ohms. If it were not, 10 volts would have caused some other current to flow through the circuit. In the case of 100 volts and 100 ma., the circuit resistance must have been 1000 ohms. This follows simply because of our old friend Ohm's Law, which says $I = E/R$, where I is the current in amps, E is the voltage, and R is the resistance in ohms.

We can now get back to what we were originally discussing, namely power amplifiers and voltage amplifiers, and see just where the difference lies. In the circuit of the set we are discussing, the triode section of $V_2$ is a voltage amplifier. Its job is to take the input voltage from the detector diode, and to provide an enlarged replica of this voltage at the grid of the pentode section. This section has a grid leak of 1 meg., which is so high a resistance that the current through

it caused by a few volts of signal is very minute. Thus, the power required to cause the needed voltage across the grid leak $R_3$ is very minute too.

By way of contrast, we have the second audio stage, which has to feed the loudspeaker. This is a device whose resistance to signal currents is very low—only a few ohms—so that if the speaker takes an appreciable fraction of a watt to work it, this means that a few volts will have to be developed across the secondary winding of the transformer that feeds the speaker from the valve. Now one volts across, say 3 ohms (which is roughly the effective resistance of the speaker) represents a current of 1/3 amp., and therefore a power of 1/3 watt. This power has to be delivered by the pentode amplifier valve, so that this is called a *power* amplifier. If we were to look only at the voltages, we would not say that the pentode had produced any amplification at all, because the voltage delivered to the speaker is actually less than the voltage given to the grid. But the very minute bit of power taken by the grid circuit has been transformed into about a third of a watt, which is quite an appreciable amount, so that the valve really does amplify.

Strictly speaking, as we have already said, any amplifier does so only because it gives more power at the output than was put in at the grid, but the term *power amplifier* is reserved for the case of the valve which has to provide enough power to operate a cutting head, for recording, a speaker, for listening, or any other similar device which needs power to work it. To return to our imaginary electric motor, we can even use a valve amplifier to provide the power to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run a motor, and for some special purposes, this is actually done!

In a later instalment we will have to say something about the transformer, and why it is needed, although from what has gone before, readers should have a clue to this already!

## BUILDING THE SET

Reproduced here are two photographs of the original set that was built to illustrate in a practical way the points we have been discussing. The chassis is a simple U-shaped one made of 18 or 16-gauge aluminium, which is easily bent and worked in an amateur workshop not over-supplied with tools. In the centre of the chassis is mounted the two-gang condenser, which is of the midget type with a celluloid dust-cover. Looking from the front we see $V_1$ at the right-hand corner and just behind it is the aerial coil $T_1$, almost obscured in the photo. Behind that again can be seen the aerial and earth terminals. In the opposite corner of the chassis is the 1D8-GT. The detector coil, $T_2$ is not to be found on top of the chassis, but is underneath, and can be seen screwed to the front flange of the chassis in the underneath view. The white object immediately on its right is the trimmer condenser, whose connecting lugs are soldered directly to those of the coil. In the top view, the trimmer across the aerial coil can be seen similarly.

In the top view, the two shafts coming through the panel are those for the volume control and the on/off switch. The latter is on the left, in this view, so that in the under-chassis view, it is the one on the right, since the set has been turned upside-down. The large condenser in the middle of the chassis, with the resistor across it is $C_5$, and the resistor $R_6$. This goes from a spare lug on the $V_2$ socket to an earthed lug clamped under the mounting bolt on the socket of $V_1$. There are not very many other small parts, and these are fitted in as near to the parts of the circuit that they belong to as possible.

No terminals have been provided on the back of the set for the attachment of the battery leads, but these have been wired into the circuit, and are taken through a rubber grommet which can be seen in the underneath view right at the back centre of the chassis. The filament + lug on the $V_2$ socket is used to attach the positive A battery lead, and the filament — lug is used for the negative A lead. The B + lead is attached to the screen-grid terminal of the pentode part of the 1D8. It must be remembered in wiring this set that B— is not taken to chassis, but must go to the un-earthed end of $C_5$. If this is not done, there will be no grid bias on $V_2$ and the valve will be ruined in short order.

Except for these few words of advice, there is not much help that can be given to those building this set. Make everything as neat as possible, as long as this does not mean long leads in that part of the circuit which carries signals, either R.F. or audio frequency. Some leads, such as filament and B leads cannot be kept short, and doing so serves no useful purpose anyway. But strive for a neat-looking job as well as one which works. Very often, the one automatically means the other, if only because neat works is less likely to contain wiring errors!

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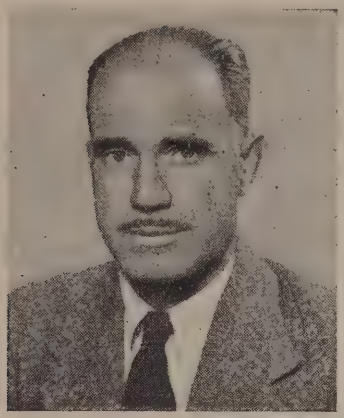

MR. A. WEBB

Alec Webb, well-known managing director of Webb's Radio Ltd., Auckland, left with Mrs. Webb during March for an extended holiday trip to Australia and England. Alec is a veteran of the radio industry; a pioneer of the good old battery days. Starting his career with Messrs. A. H. Nathan over 25 years ago, handling Kellogg and later Columbus Radios, Alec went through all the "Ifs" and "Buts" of the marketing and servicing of this then new industry. Today, as head of a prosperous manufacturing and retail business, he expects during his stay in England, to see something of the "ways and means" of the radio set-up there, and we are sure that Alec will gain much of interest from a business point of view, and also enjoy meeting the Home folks socially.

During his absence Mr. D. L. Rhodes will manage Webb's Radio Ltd. and Herb. Wilson will ably assist.

To Mr. and Mrs. Webb we send our heartiest greetings for a successful trip.

* * *

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Despite considerable damage to their Temuka premises, when, on the evening of Friday, 3rd March, fire destroyed approximately one-third of the main block, we are pleased to report that N.Z. Insulators Ltd. are again in production, and are hopeful that full output will be achieved in a relatively short time.

Much of the most important machinery was undamaged, and re-building of the burned-out area is to commence immediately.

* * *

The N.Z. Institute of Industrial Management held a successful meeting in February, at the premises of Radio (1936) Ltd. Mr. Clifton Lewis says it was most encouraging to see the interest taken in the subject matter of business management. Four short lectures were presented by executives of individual member firms. There were about 300 present, including 10 members of the staff of Radio (1936) Ltd.

* * *

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Overseas visitors to New Zealand in March included Mr. H. V. Slade, managing director of the Garrard Engineering and Manufacturing Co. Ltd., England. He was met by Mr. and Mrs. Paykel (Fisher and Paykel, Ltd.) in Wellington, and after a few brief contacts in that city, left for an extended tour of the South Island. It is expected that Mr. Slade will have time for longer contacts with the trade in the North Island before he returns Home.

MISS D. C. JAMIESON

*Miss Dorothy Jamieson, who has been a member of the staff of "Radio and Electronics" since 1948 has just left New Zealand on an extended trip to Great Britain and the Continent. She expects to be away for approximately eighteen months, and will be sadly missed in our office, where her efficiency and good humour have made her well nigh invaluable, especially round publishing date! Her many friends in the industry, and our many clients, will, we are sure, join with us in wishing Miss Jamieson a very happy and enjoyable time abroad.*

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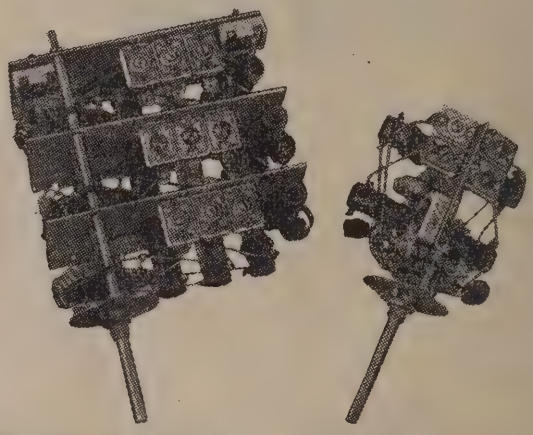

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A Ticonal magnet supplies maximum energy within the gap, which is held within fine limits by the accurately machined locator, making it impossible for the assembly to be knocked out of centre. A special version of the speaker is available to order for fitting in low-frequency horns of the type used in dual-channel installations in cinemas. This has a natural tone resonance of 30 cycles.

### Specifications

| | |
|---|---|
| Power handling capacity | 40 watts |
| Cone resonance | 42 c.p.s. |
| Total useful flux | 260,000 lines |
| Voice coil impedance | 15 ohms |
| Voice coil diameter | 2¼ in. |
| Piston diameter | 11⅛ in. |
| Diameter of baffle opening | 13 in. |
| Net weight | 23½ lb. |


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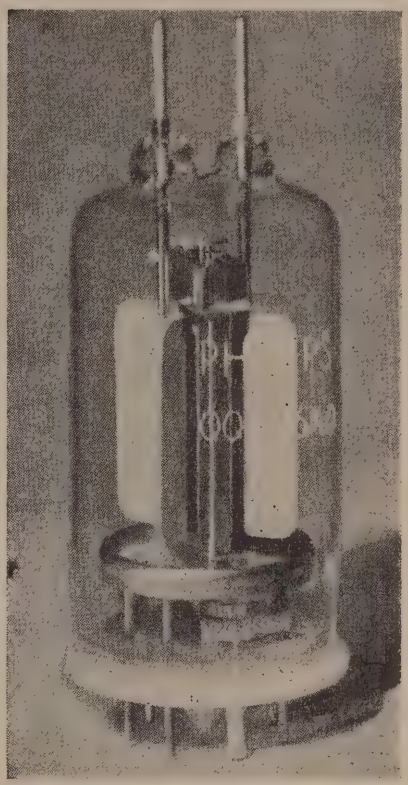
### A NEW TRANSMITTING VALVE



One of the latest and most interesting transmitting valves to be seen in this country is the Philips QQE06/40, pictured above. It is a double pentode with common cathode construction, and is similar in characteristics to the American type 829B. Its frequency ratings are rather better than those of the latter tube, and it can be used as a replacement, since the socket connections are the same, and an identical socket is used. An interesting feature of its construction is the built-in screen by-pass capacitor, which makes an external condenser unnecessary in some applications, and allows the use of a normal condenser, not necessarily of particularly low residual inductance, external to the tube.

The QQE06/40 can be used as a straight amplifier in push-pull circuits without neutralization, when care is taken to shield the input and output circuits from each other. Its plate dissipation is 40 watts, and it requires an H.T. voltage of only 600 for 120 watts input under plate-modulated conditions.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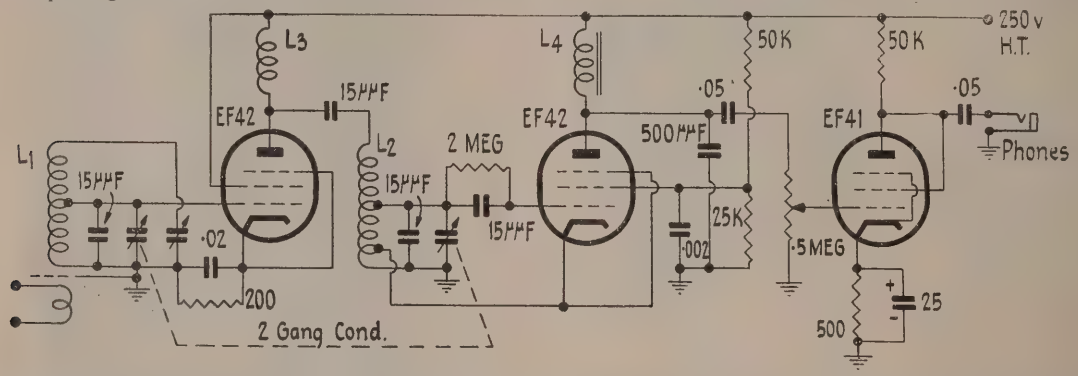
# The PHILIPS Experimenter

## AN INEXPENSIVE RECEIVER FOR 6-METRE DX

How many amateur transmitters would like to work 6-metre DX when the band is open, and yet are deterred by the fact that they have no receiver for this frequency? The band is not open very often for DX working, so that an expensive receiver or converter would eat its head off for most of the year, doing nothing. And most of us cannot afford to have relatively expensive gear lying idle. One solution, we think, is to build a receiver for the 50–54 mc/sec. band that does not cost very much, and yet which has ample sensitivity, but here the difficulty is that sensitivity is not usually to be had except at a price—with one notable exception. This, of course, is the super-regenerative set. And lest there be some




who will at this point metaphorically turn their noses up and refuse to have any more to do with the idea, let us remind them that these days, the humble super-regenerative is by no means to be sneezed at. During the war, there were probably more super-regenerative receivers in action than any other kind of receiver, and these were the now well-known I.F.F. receivers, used to receive our own radar transmissions in our own aircraft, for purposes of identification. Now these sets had to be reliable, as upon them depended a most important tactical piece of knowledge. They also had to be extremely sensitive, whereas selectivity was a minor consideration. They therefore filled the bill admirably, and there is no reason why today, amateurs should not make use of some of the modern knowledge of this kind of receiver for their own purposes.

One of the main disadvantages of the super-regenerative is that it radiates quite strongly, unless precautions are taken to prevent this from happening. In the radar applications of this set, the radiation of the receiver was unimportant and was, in fact, purposely reinforced, in a special way, to suit the object in hand. Previously, the main reason for using the super-regenerative was its extreme simplicity, and the fact that it could be made to work where conventional circuits, such as R.F. amplifiers, failed to function. It can still be used in this way, at ever higher frequencies, but at comparatively low ones, such as six metres, we now have the means to add a stage of R.F. amplification to the super-regenerative detector, and thus make a set with extra selectivity, more reliable operation, and no radiation to speak of.

This, then, is the kind of set we have decided upon. It uses three valves only—an R.F. stage, a super-regenerative detector, and one of audio amplification. The first two valves are EF42's. These are the new "Rimlock" high-slope pentodes, and are just what is needed for the sort of thing we are doing. A glance at the circuit will show that the number of parts used is small, and that the power supply requirements are particularly light. The set therefore does not need a separate power pack, and will be inexpensive to build, as most of the parts, apart perhaps from the valves, can be found in the "junk-box."

Since this is a single-band receiver, it is a comparatively simple matter to provide complete band-spread, and this has been done.

### THE CIRCUIT IN DETAIL

At first glance, the circuits of the R.F. and detector stages may seem a little strange, but there are good reasons for this. Both valves are tapped down their respective coils, for the purpose of reducing the loading on the tuned circuits, and at the same time to make it easier to spread the band over the dial without using ridiculously small capacities. At the higher frequencies, it is always a help if reasonably large condensers can be used, as adjustment is rendered easier thereby. Tapping down enables a high-gain coil to be obtained without using very small capacities, and increases the Q and therefore the selectivity of the circuits at the same time. It might appear that all the tapping down does is to reduce the signal voltage that is applied to the grids of the valves, but this is by no means always the case. In allowing the coil to have a higher Q, as it undoubtedly does, the loss of signal voltage is more than made up for, unless the grids are tapped a very long way down, and in practice, tapping them to the mid-point, as is done here, results in a net gain over the more usual arrangement. The reason for this can be appreciated, when it is realized that the effective shunt resistance is divided by *four*, while the signal applied to the grid is divided only by *two*. The same thing goes for the capacity. The effect of the tubes' input capacity is divided by four, when the grid is tapped half-way down, so that an input capacity of, say 4 $\mu\mu$f. appears as only 1 $\mu\mu$f. shunted across the whole coil. This again enables circuits to be used which have a high ratio of inductance to capacity, which further increases the coil's gain, and also the valve's gain, too. In fact, so many are the advantages of tapping down, that it is well worth the bother of making the extra coil connections. At lower frequencies, where coil gains are higher, the valve input resistances are higher too, such

a procedure does not always pay, but above 30 mc/sec., it most certainly does.

The aerial coil is thus tapped at its centre. At this point are connected both the grid of the R.F. amplifier, and the main tuning capacities. Across the whole coil is connected a Philips trimmer. This can be a 3–30 $\mu\mu$f. condenser, but if one is available, a 1–10 $\mu\mu$f. trimmer of the same kind would be preferable. This is because only about 4 to 5 $\mu\mu$f. is actually needed, and it might even be found that the minimum capacity of the 3–30 kind is just the required capacity.

The R.F. stage is cathode biased, in the usual way by a 200-ohm resistor, by-passed by a 0.02 $\mu$f. condenser. This is purposely made smaller than is used in low-frequency circuits, because the smaller value is likely to be more effective, on account of the residual inductance of the larger values. A 15 $\mu\mu$f. fixed silvered mica condenser is also connected from the tap to ground on the coil, and this, in conjunction with the trimmer, acts to pad up the minimum capacity for band-spreading purposes. It is needed because the variable part of the circuit capacity is a midget two-gang condenser, which has a particularly low minimum capacity. This gang is a Polar, of 6 to 17.5 $\mu\mu$f. per section. Thus, the total minimum capacity across the coil tap is 21 $\mu\mu$f. This has the same tuning effect as just over 5 $\mu\mu$f. connected across the whole winding, so it is easily seen how much easier the adjustment and choice of suitable capacities is when the coil is tapped.

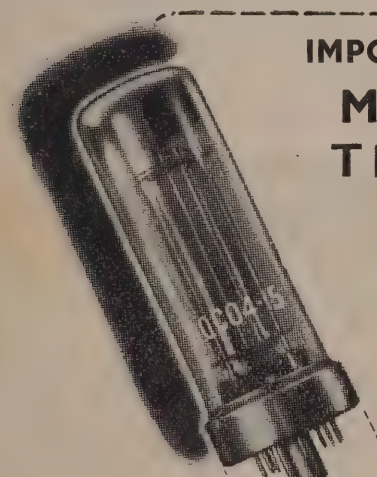
The R.F. amplifier is shunt-fed, having a 2.5 mH. choke in its plate circuit, and a coupling condenser of 15 $\mu\mu$f. to the second coil, in the grid circuit of the detector. This coil is identical as to number of turns, etc., with the R.F. coil, and is also tapped at the centre. The 15 $\mu\mu$f. fixed condenser is connected across the lower half of the coil, as with the R.F. coil, but this time there is no trimmer connected right across the coil. This is because we now have the output capacity of the R.F. stage, whereas the aerial coil does not have a corresponding capacity until we connect the trimmer across it.

The EF42 is one of those convenient valves which are able to have the screen-grid operated at the full plate potential. As a result, no screen dropping resistor, or by-pass condenser are needed on the R.F. stage. The suppressor is brought out separately, and so is connected to cathode at the valve socket.

## THE SUPER-REGENERATIVE DETECTOR

Since the EF42 is such a good valve for R.F. amplification at the frequency at which we are working, it can be expected to be equally good as a super-regenerative detector. Most circuits for the latter use either a triode, or a pentode connected as a triode. However, there is no reason why a pentode cannot be used in a super-regenerative circuit, as long as it is an efficient oscillator at the frequency concerned. Nor is there any necessity for any particular oscillator circuit to be used. Here, we have demonstrated this fact by using the electron-coupled oscillator circuit. This particular one is very successful

**(Continued on page 41)**

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# TRADE WINDS

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The ideal hearing aid must combine efficiency and compactness: if the instrument works well but is bulky, the user may be embarrassed by the attention drawn to his affliction; if it is small but does not considerably improve hearing its main aim has been missed.

Present trends in deaf aids favour a model containing its own battery. This arrangement tends to be bulky; the bulk can be most easily reduced by improving the valves. If smaller, and also consuming less power, they will themselves need less room and enable efficiency to be maintained with a tinier battery.

Mullord valves DF66 and DL66 do precisely this. Flat in shape, their minute dimensions are space-saving: width, 0.33 in. (8.5 mm.), thickness, 0.24 in. (6.1 mm.), length (according to type), 1.1 in. (28 mm.) or 1.38 in. (35 mm.). To enable smaller batteries to be used, filament current requirements have been brought down to 30 milliamperes—a third less than the requirements of most present aids. This improvement depends on mass production of filaments roughly 10 times finer than a human hair, with a diameter of under 8 microns (3/10,000 in.).

A 5 oz. (142 gm.) hearing aid, efficient and compact, should soon result from these advances—the greatest to date in this exacting field.

## IMPROVED TESTING DEVICES

Speedier, easier coil testing results from new British devices. They should prove a boon to most electrical and wireless manufacturers.

Coils are vital components of much electrical equipment. Small defects in them may easily lead to large breakdowns. The essential but arduous task of testing against imperfections can now be greatly lightened with the Turns Checker and the Short Circuited Turns Tester made by Samwell and Hutton of Ilford, Essex.

Electric motor windings are investigated with the Turns Checker. The coil under test is placed on a magnetic cored jig: a meter shows the number of turns. Coils of similar shape can be quickly sorted like this. The special detector allows turns to be measured to an accuracy of one turn or 0.5 per cent.

The Turns Tester detects short circuits in coils wound on bobbins. Speed and simplicity of operation being its main features, it is ideal for production testing of radio and television coils, gramophone pick-up bobbins, etc. The coil is placed on the probe and a meter shows if turns are shorted. No wires have to be connected; coils can be tested just as fast as they can be handled. Continuity is checked by simply shorting the coil terminals before taking it off the probe. A relay cuts out the meter—protecting it from overload—and a lamp lights when the coil is satisfactory.

## PUBLICATIONS RECEIVED

From Industrial Electronics Ltd.: Bulletins and Catalogues of Brookes Crystals Ltd. (Eng.), British Communications Corp. Ltd. (Eng.), Clifford and Small Ltd. (Eng.), Collins Radio Co. (U.S.A.), Dawe Instruments Ltd. (Eng.), Electro Methods Ltd. (Eng.), W. Mackie & Co. Ltd. (Eng.), Industrial Electronics (Eng.), Wimbledon Engineering Co. Ltd. (Eng.).

W. G. Leatham Ltd.: A Series of Bulletins from Electronic Instruments Ltd. (Eng.), Vitavox Ltd. (Eng.).

Philips Electrical Industries Ltd.: Valve Data Book (published at 1/6d).

C. & A. Odlin: Mullard Technical Report, "Some Applications of Sub-miniature Valves."

Ellis & Co.: Publication No. 1119, Crabtree Round the World, and Crabtree Electrical Products, Export Price List.

The following publications have been received from the undermentioned firms:—

C. S. Stewart, Ltd., Wellington.—Descriptive bulletin entitled "Mycalex" Insulating Mouldings.

Ducon (N.Z.), Ltd.—Advance copies of two bulletins covering noise-suppression capacitors and power factor correction, copies of both of which will be available to the trade shortly.

His Master's Voice (N.Z.), Ltd.—"Listeners' Guide"—a booklet of 16 pages containing interesting history of the famous "Nipper" trade-mark. Service Manual of the Buckingham Radiogram; 21 pages of complete specifications, installation and servicing procedure, with a comprehensive spares list. A volume of technical data covering individual models. This is in a permanent binder in which allowance has been made for the insertion of extra sheets.

C. & A. Odlin, Ltd.—Mullard Valve Data Booklet—a pocket-book size. This covers essential data on a wide range of valves, direct equivalents, near equivalents, and substitution for non-current types. Mullard window stickers are also available on request. Brochure of Hayman Laundry Equipment and Utility Electrical Appliances for the home.

Amalgamated Wireless (A/sia), Ltd., Wellington.—Publication No. 10 of the Telegraph Construction and Maintenance Co., Ltd., England, covering "Telcon" cables for radio frequencies. Also a range of literature covering "Cintel" products of Cinema-Television, Ltd., England, featuring test gear, special tubes, timers, recorders, etc.

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# THE "RADEL" 1950 ALL-WAVE SEVEN

## CONSTRUCTION

The cover photograph of last month's issue and the working drawing for the chassis give a good idea of the lay-out of the main parts. The coil unit is not mounted centrally on the chassis, but to the right a little, as can be seen in the underneath photograph. The gang condenser is placed almost over the centre of the coil unit, and a little towards the right. Then, in a row from front to back, to the right of the gang are the 6BA6, the X61M, the first I.F. transformer, and the 6AR7. The latter is in the corner of the chassis. The circuit then progresses along the back of the chassis, with the second I.F. transformer, the 6SN7, and the two KT61's. In front of these are the power transformer, the smoothing choke, and the rectifier tube. The latter is partly hidden in the photograph, but can just be seen between the transformer and the choke.

A slide-rule type of dial is used, with the spinner right at the right-hand end of the chassis. The two large holes in the front of the chassis are for the string to pass through on its way to and from the spinner shaft.

The underneath view shows how comparatively free from small parts is the "front end" of the set. The only part of the set where it may be found a little difficult to fit in the condensers and resistors is in the vicinity of the 6SN7. The volume control potentiometer is on the extreme left of the chassis, and its shielded leads can be seen skirting the coil unit and going to the second I.F. transformer. In wiring this part of the circuit it is important to see that the I.F. filter is placed as close as possible to the I.F. transformer. The shielded leads to the volume control do not then have so much shielding to do, since practically all of the I.F. voltage is removed by the filter before the shielded lead is reached. The shield braid should be welll earthed, preferably to several points on the chassis. In our case, an aluminium chassis was used, so the earthing points had to be solder lugs tightly clamped between the chassis and the mounting nuts of valve-sockets, etc. The earthed end of the volume control potentiometer should be earthed to the end of the shield braid, and the case of the potentiometer should also be connected to the same point. This makes the cover of the pot. an effective shield for the "works" inside, and as well as helping to bypass any residual R.F., it also aids in keeping any hum from getting into the volume control by capacitative coupling (as sometimes happens). The voltage divider can be seen at the left of the under-chassis view. These somewhat old-fashioned components seem to have re-appeared on the market after a long absence, and they are extremely useful, and much cheaper than a pair of conventional high-wattage wire-wound resistors would be. It will be noticed that two tappings can be made by means of the sliding connections, but only one of them is used in this set.

There is little else one can say about the wiring of the set, since this must follow the logical arrangement of the main parts. Nor is there anything at all out of the ordinary in the circuit or its adjustment that needs explanation. The alignment is straight-forward, and can


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be carried out by any of the stock methods, using a signal generator, a multivibrator, or both. It has just occurred to us that the multivibrator as an alignment tool is far too much neglected, especially by those of use who cannot afford a signal generator; an article on the use of this extremely cheap and versatile instrument would certainly not go amiss.

The I.F. transformers shown in the photograph are condenser-tuned ones, with fixed iron-dust slugs, but there is no reason why permeability-tuned transformers should not be used if desired.

While there is certainly nothing startling, or even new about the design of this set, its excellent performance, which it derives from the use of some of the most modern valves currently available, should appeal especially to those builders who are also DX enthusiasts, while the simple but effective push-pull output system should find many "buyers" among those whose cry is for better audio quality than the average set will give. We suggest that a good 12 in. speaker would be a very good investment for this set, and would really give some idea of the excellent quality of which it is capable.

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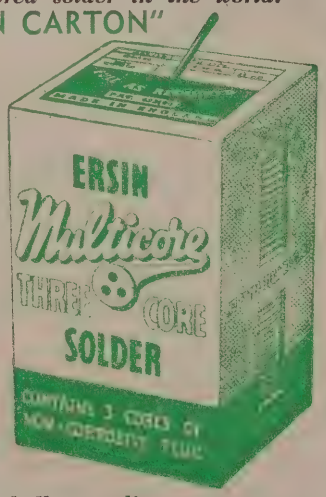


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# REDUCING HEATER HUM

One of the difficulties that the quality enthusiast encounters is that of amplifier hum, especially when high gain has to be used, or when in special circuits, such as volume expanders, it is necessary to work with a low signal level. When efficient low-frequency speakers are used, in a vented or bass-reflex baffle, the hum that is present is liable to be reproduced in a manner that renders it far from harmless, even in cases where the same amplifier sounds hum-free on a speaker that is not so well baffled. There seem to be remarkably few methods of dealing with heater hum, except the old and well-known expedient of connecting a low-resistance potentiometer across the common heater supply, with the moving arm grounded. Then the pot. is adjusted for minimum hum in the output. We can leave out of consideration hum other than that found to be due to the heaters of the valves, because this can always be reduced to negligible proportions by suitable filtering, which these days is easy and inexpensive to apply in effective quantities.

The potentiometer method described above is usually called in England a "humdinger," but unfortunately, it is not very effective in removing hum generated in the low-level stages of an amplifier unless it is applied separately to all the early valves. This necessitates a separate heater winding and potentiometer for each valve, and this is liable to become rather expensive. In the ordinary way, one is driven to the use of D.C. on the valve heaters, in really high gain amplifiers.

Quite recently, however, Britton and Baylis, have developed a method which appears to have excellent possibilities, and which is based on their discovery that the contribution to the total hum that is made by each valve is in phase with the heater voltage at the terminals of that valve. The solution is therefore to introduce into each valve a small amount of hum that is in anti-phase with that caused by the heater. This can be done in several very simple ways—so simple indeed, that a circuit diagram is not necessary in order to explain them. Moreover, to put the scheme into operation it is not necessary to have more than a single heater winding for the whole amplifier.

When heater hum arises, it may do so in any or all the valves in the amplifier circuit, but only in the low-level stages will any audible effect result. This is because in any stage handling several volts, quite large amounts of hum, relatively speaking, can be tolerated because they are swamped by the signal. Supposing, therefore, that only one low-level stage occurs in the amplifier—it may be a microphone pre-amplifier or one for a low-level gramophone pick-up—it will then need only one potentiometer and two resistors, or two potentiometers, to render the hum harmless, and to all intents and purposes, non-existent.

The first step is to remove the valves that handle, say, less than a volt of signal at their grids. These are the ones that will be specially "treated" for heater hum. Next, at a point near the last of these, two 50-ohm resistors are connected, one from each heater lead to earth. These form a fixed "humdinger" for the valves that remain. If there happens to be a centre-tap on the heater winding of the power transformer, this should be disconnected from earth, and if the heater winding is centre-tapped already, at some point near the power transformer, by means of a similar pair of resistors, these should be discarded. The object of having the centre-tapping resistors close to the low-level valves is to prevent possible trouble from heater frequency currents flowing in loops of which the chassis forms one leg. When this has been done, the amplifier is turned on, and a listening test is conducted to see whether any hum can be heard. During this test, the grid of the first valve should be short-circuited to ground so that "open-grid" hum will not obscure the true state of affairs. If all is well, one can now proceed to the next step, which is to perform the hum-cancelling operation on the last low-level tube. To do this, the low-resistance potentiometer (its exact value is not important, and it can have a total resistance of up to 1000 ohms) is connected across the heater as near as possible to the socket of the valve that is being treated. So far, the moving arm is left unconnected. More than likely, the valve will be a pentode. If this is so, it will normally have its suppressor-grid connected either to earth or to ground. This connection is broken, and a wire taken from the suppressor pin to the movable tap on the potentiometer. We are now ready to start adjusting. This is easy, as all that has to be done is to adjust the potentiometer for minimum hum, and in most cases it will be found minimum is the same thing as zero! If there is only one low-level valve, the process is now complete, but it should be emphasized that *once the potentiometer has been adjusted, it should not be touched again if there are other valves in front of it which have to be treated as well.* In other words, if more than one valve is to be treated, they are plugged in *successively* in reverse order to their appearance on the circuit diagram, and "treated" in turn. When each valve

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is replaced, the adjustments that have been made for the following ones should on no account be touched, or the whole adjustment process will have to be done again.

### OTHER METHODS

In bad cases, it may be found that the suppressor of a pentode does not give enough sensitivity for the method to give complete cancellation. This may be so because the amplification of the unintentionally injected hum, which appears in the grid circuit, is very much greater than that given to the purposely injected voltage at the suppressor. Also, in some cases, the valve may be a tetrode, and have no suppressor on which to operate. If either of these things is found to be the case, one can instead inject the intentional hum voltage into the screen circuit. In the former case, the amplification will be greater, and not such a large voltage will need to be injected. The injection via the screen is done by lifting the screen by-pass condenser from ground, and connecting it instead to the moving arm of the potentiometer. Adjustment is carried out in the same way as for the suppressor injection.

If the valve to be treated is a triode, a certain amount of compensation can be had by lifting the cathode by-pass condenser from earth and connecting it instead to the potentiometer, as in the other methods. However, this does not give as complete cancellation as when a pentode or triode is used. For this reason, it may be preferable to substitute a pentode for a triode even if the extra gain is not required. A voltage divider can be made by splitting the following grid resistor into two parts, and this can be proportioned so as to reduce the over-all gain to the desired figure.

A criticism that may be levelled against the kind of hum suppression that has just been described is that when valves are changed, the suppression circuit will need adjusting again. This does not seem to be a very heavy price to pay for hum-free operation. The authors referred to in the reference have stated that by the use of their suppression method it was found possible to build an amplifier with very high gain—so high that the thermal agitation noise was quite loudly reproduced at maximum gain—and yet to have the hum level so low that it could not be heard against the thermal noise. It is hard to imagine greater freedom from hum than this, and the result is far more cheaply attained than by other "last ditch" methods. For instance, the writer knows of one enthusiast who is in the process of building a very complex system, in which all valves except the power amplifier tubes have their heaters supplied from a power supply designed to give 300 ma. at something over 120 volts. He should certainly get his hum-free operation, but at a price that not very many can afford to pay!


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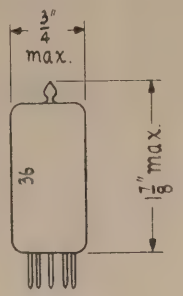
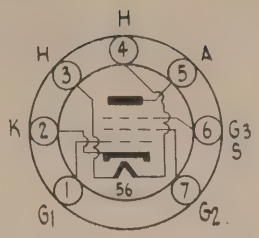
# TUBE DATA

Recently, a new series of A.C. miniature tubes has been released, both in England and America. The nomenclature has been standardized, and so has the nine-pin Noval base that some of the tubes use. We have pleasure in announcing that data on these valves will appear in our "Tube Data" section, the characteristics and curves having been made available through the courtesy of Messrs. Standard Telephones and Cables Pty. Ltd.

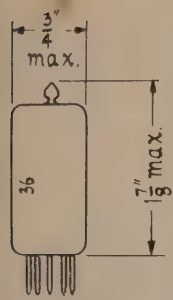
This month we feature the base connections and characteristics of types 6AM5 and 6AM6. The former is a power pentode, while the latter is a high-Gm sharp cut-off R.F. pentode. Both types use the standard B7G miniature socket.



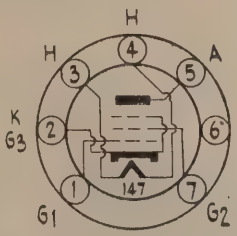
B7G Base.




## TYPE 6AM5



B7G Base




### RATINGS

| | |
|---|---|
| Heater Voltage | 6.3 volts |
| Heater Current | 0.2 amp. |
| Anode Voltage | 250 volts |
| Anode Dissipation | 4.0 watts |
| Screen (G2) Voltage | 250 volts |
| Screen Dissipation | 0.65 watt |

### OPERATING CHARACTERISTICS (CLASS A)

| | Single Valve | 2 Valves | |
|---|---|---|---|
| Anode Voltage | 250 | 250 | volts |
| Anode Current | 16 | 22 | mA |
| Screen Voltage | 250 | 250 | volts |
| Screen Current | 2.4 | 3.2 | mA |
| Control Grid (G1) Voltage | —13.5 | —15 | volts |
| Cathode Bias Resistor | 750 | 600 | ohms |
| Anode Impedance | 0.15 | — | meg. |
| Mutual Conductance | 2.6 | — | mA/V |
| Optimum Load | 16,000 | 24,000 | ohms |
| Power Output | 1.4 | 4.0 | watts |
| Harmonic Distortion | 10 | 3.2 | per cent. |

### INTER-ELECTRODE CAPACITANCES

| | |
|---|---|
| Input | 4.2 pF. |
| Output | 3.2 pF. |
| Grid to Anode | 0.5 pF max. |

* * *

## TYPE 6AM6

### RATINGS

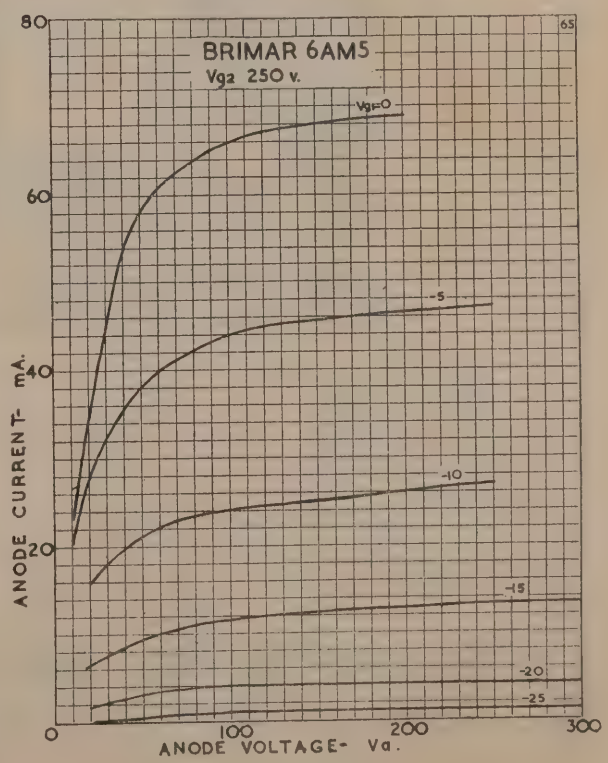
| | |
|---|---|
| Heater Voltage | 6.3 volts |
| Heater Current | 0.3 amp. |
| Anode Voltage | 250 volts max. |
| Anode Dissipation | 2.5 watts max. |
| Screen (G2) Voltage | 250 volts max. |
| Screen Dissipation | 0.8 watts max. |

### OPERATING CHARACTERISTICS

(Suppressor Grid ($G_3$) connected to Cathode)

| | | | |
|---|---|---|---|
| Anode Voltage | 200 | 250 | volts |
| Anode Current | 9.0 | 10.0 | mA |
| Screen Voltage | 200 | 250 | volts |
| Screen Current | 2.25 | 2.6 | mA |
| Control Grid (G1) Voltage | —1.5 | —2.0 | volts |
| Cathode Bias Resistor | 135 | 160 | ohms |
| Anode Impedance (approx.) | 0.8 | 1.0 | meg. |
| Mutual Conductance | 7.5 | 7.5 | mA/V |
| Input Resistance at 45 Mc/s | 7,000 | 8,200 | ohms |
| Control Grid Voltage (For Cathode Current cut-off) | —4.5 | —5.5 | volts |
| Working Input Capacity | 10.4 | 10.1 | pF |
| Change in Input Capacity (G1 biassed to cut-off) | 2.3 | 2.0 | pF |

(Continued on Page 48.)



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1400 Sound Level Meter
500 Distortion Factor Meter

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# THE "CITIZENS BAND" IN THE U.S.A.

*By the Engineering Department, Aerovox Corporation*

On 1st June, 1949, the Federal Communications Commission inaugurated the Citizens' Radio Service on a regular licensing basis. Prior to that time, stations operating in this band (460–470 mc.) were governed by experimental rules pending finalization of the new regulations by the FCC. The new service provides, for the

FIG.1

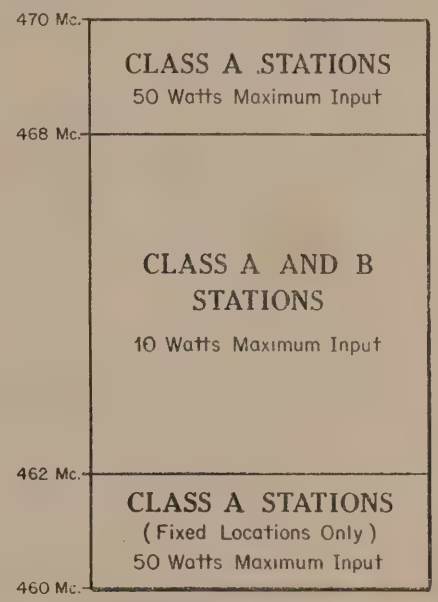
first time, means whereby a private citizen may engage in two-way radio communication without being required to pass a technical examination.

Because of the simplicity of the new licensing procedure and the long-standing need for such a service, it is anticipated that the citizens' band will become a very important aspect of ultra-high-frequency radio. This article contains a general discussion of the rules controlling this service, the technical requirements of the equipment employed, the possible applications of citizens' stations, the propagation characteristics of this portion of the UHF band, and the implications of this new service in the servicing and manufacturing fields.

## REGULATIONS

The detailed regulations governing the Citizens' Radio Service may be obtained from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., for a fee of five cents. This reprint from the *Federal Register* of 5th April, 1949, is designated "F.R. Doc. 49–2517." Application for Citizens' Radio Service construction permit and station licence may be made on FCC Form 505 to FCC Field Engineering Offices or to Washington, D.C.

In general, the rules provide for the operation of a citizens' radio station by any citizen of the United States who is over 18 years of age and who possesses citizens' band equipment *which has been approved by the FCC*. The licensing procedure for those thus qualified is quite "streamlined," requiring merely the submission of the non-technical, single card application form (Form 505). The normal term of the licence is five years from the date of issuance. It authorizes the holder to communicate with the other Citizens' Radio Service licensees on a frequency-sharing basis for pleasure, utility, or indirect profit. By "indirect profit" it is meant that the service may be used as minor instrumentation in a business. For instance, a doctor might use the citizens' band for a private call system to maintain contact with his home or office. The service may *not* charge for messages, handle programme material in any way connected with radio broadcasting, transmit directly to the public through public address systems, or for other purposes contrary to Federal, state, or local law. The FCC regulations define the Citizens' Radio Service as "a fixed




CITIZENS-BAND FREQUENCY ALLOCATIONS

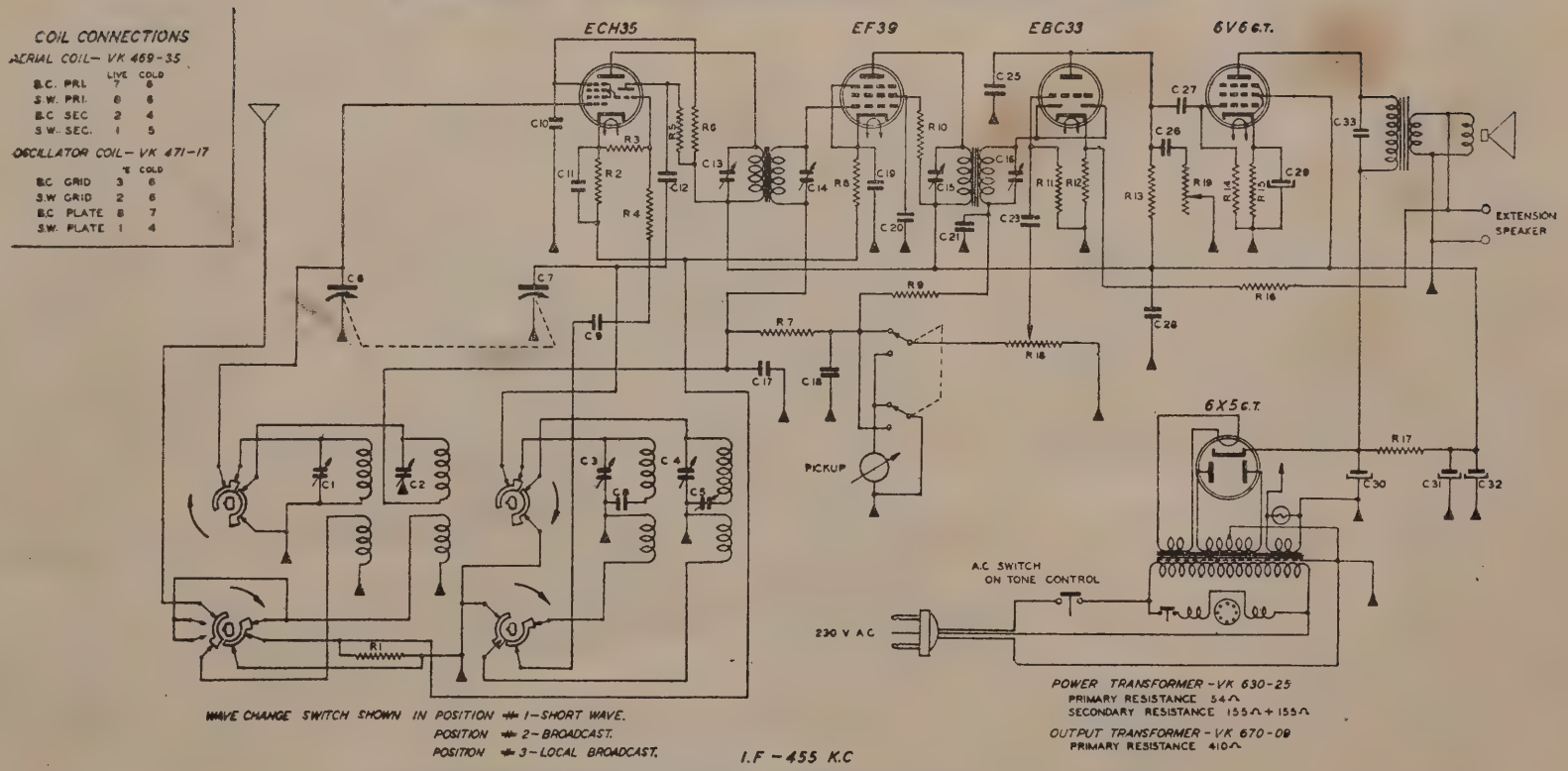
FIG.2

and mobile service intended for use for private or personal radio communication, radio signalling, control of objects or devices by radio, and other purposes not specifically prohibited herein." The artist's sketch of Fig. 1 illustrates the most popular concept of such "personal radio communication."

Due to the non-technical nature of the citizens' licence requirements, this frequency allocation is not intended as an experimental band. All station equipment must be type approved by the FCC before the issuance of a station licence. Any transmitter adjustments or maintenance which might affect its operating characteristics must be made by, or under the direct supervision of, the holder of a first- or second-class commercial licence. The Commission must be notified of any major modifications which are made to the equipment during its use.

The regulations do, however, provide for the licensing of "composite equipment which complies fully with the technical requirements of the Citizens' Radio Service." The procedure for obtaining FCC approval for the construction and operation of such equipment is considerably more complicated than that outlined above for the case of commercially manufactured, type-approved equipment. Supplementary information, describing the complete design and testing of the composite equipment, must be submitted to demonstrate that it will comply with the

# PHILIPS RADIOPLAYER — MODEL 599




## CONDENSER AND RESISTOR VALUES

C1 3-30 mmfd. Trimmer
C2 3-30 mmfd. Trimmer
C3 3-30 mmfd. Trimmer
C4 3-30 mmfd. Trimmer
C5 450-600 mmfd. padder
C6 14-542 mmfd. tuning gang
C7 14-542 mmfd. tuning gang
C8 .006 mfd. mica.
C9 100 mmfd. mica.
C10 .01 mfd. paper.
C11 .05 mfd. paper.
C12 100 mmfd. mica.
C13 I.F. trimmer
C14 I.F. trimmer
C15 I.F. trimmer
C16 I.F. trimmer
C17 .05 mfd. 400v. paper
C18 100 mmfd. ceramic
C19 .05 mfd. 400v. paper
C20 .01 mfd. 600v . paper
C21 100 mmfd. ceramic
C23 .01 mfd. paper
C25 250 mmfd. mica
C26 .02 mfd. 750v. paper
C27 .05 mfd. 400v. paper
C28 .1 mfd. 500v. paper
C29 25 mfd. 25v. electrolytic.
C30 32 mfd. 350v. electrolytic.
C31 32 mfd. 350v. electrolytic.
C32 8 mfd. 350v. electrolytic.
C33 .004 mfd. mica.
R1 500 ohms ½ watt
R2 50 ohms ½ watt
R3 50,000 ohms ½ watt
R4 180 ohms ½ watt
R5 25,000 ohms ½ watt
R6 50,000 ohms ½ watt
R7 2 megohms ½ watt
R8 180 ohms ½ watt
R9 50,000 ohms ½ watt
R10 100,000 ohms ½ watt
R11 5 megohms ½ watt
R12 10 ohms ½ watt
R13 100,000 ohms ½ watt
R14 .5 megohms ½ watt
R15 600 ohms 1 watt
R16 100 ohms ½ watt
R17 1800 ohms 2 watt
R18 .5 megohms volume control
R19 .5 megohms tone control.

rigorous engineering specifications. In some cases the FCC may require that the completed equipment be submitted to its laboratory for type-approval testing. The majority of war surplus radio equipment available in this frequency range, such as the BC-645 air-borne transponder beacon, has been found by the FCC to fall far short of the required technical standards of the service.

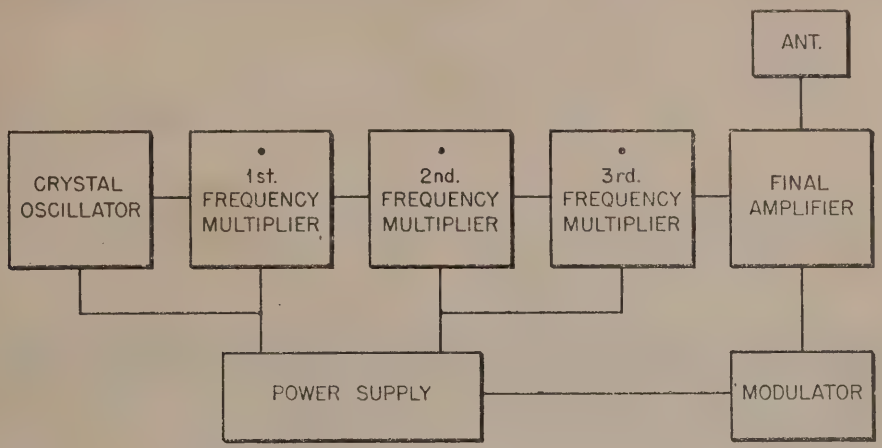
## TECHNICAL REQUIREMENTS

Two classes of licence are issued which authorize operation of a station within the 460–470 mc. citizens' band. Fig. 2 shows the allocation of frequencies in the band according to the class of licence. The Class A licence requires that the transmitter frequency be maintained constant to within plus or minus .02 per cent. of the intended operating frequency (465 mc.), and all operation must be confined to this band. The maximum power input to the final tube or tubes in the transmitter for the three subdivisions of the band is also shown in Fig. 2.

The technical requirements of the Class A licence effectively exclude all but carefully engineered, crystal-controlled transmitters. No other known method of transmitter frequency control will dependably meet the .02 per cent. tolerance specified. Since low-drift quartz crystal oscillators are available only at relatively low frequencies, it is necessary to use a multi-stage transmitter to multiply the crystal frequency to the required citizens' band frequency. The usual extent of such a crystal controlled transmitter is illustrated in block form in Fig. 3. It is common practice to accomplish the frequency multiplication in low-power stages and use the output of these to drive a high-gain power amplifier at the output frequency.

It is evident from Fig. 3 that the Class A requirements may be most easily met by stations operating at fixed locations, or in the more elaborate mobile installations. The inherent complexity of the high-stability equipment and the accompanying heavy power drain make the hand-portable "walkie-talkie" type of operation improbable. High-quality equipment is necessary for operation near the edges of the citizens' band to avoid interference with important commercial services on adjacent frequencies. The recent allocation of UHF television channels starting at 475 mc. makes the good conduct of stations in the Citizens' Radio Service even more imperative. For this reason equipment meeting FCC approval must be as "foolproof" as possible. Since it is intended for use by non-technical personnel, no control affecting the frequency of transmission should be accessible from the exterior of the equipment housing.

It is the Class B licence which is intended to authorize the operation of greatly simplified portable communication equipment which might be carried on the person in the manner of the war-time "walkie-talkie" or "handie-talkie" sets. This mode of operation has the greatest appeal to the public and probably the greatest potential field of application. The technical requirements of this licence may be met by relatively simple, lightweight sets of the "transceiver" type, in which the functions of transmitting and receiving are performed by the same tubes. Fig. 4 shows the minimum requirement for such a station in block form. The transmitter is a self-excited oscillator, modulated by one or two audio amplifier stages driven by a high-output microphone. During receiving the bias and plate voltage on the oscillator tube are switched to convert it to a super-regenerative detector. The antenna remains coupled in the same manner, and the audio section is used to amplify the detected signal and drive a small speaker or headphones. The complete transition from "transmit" to "receive" is accomplished by a single switch or relay.



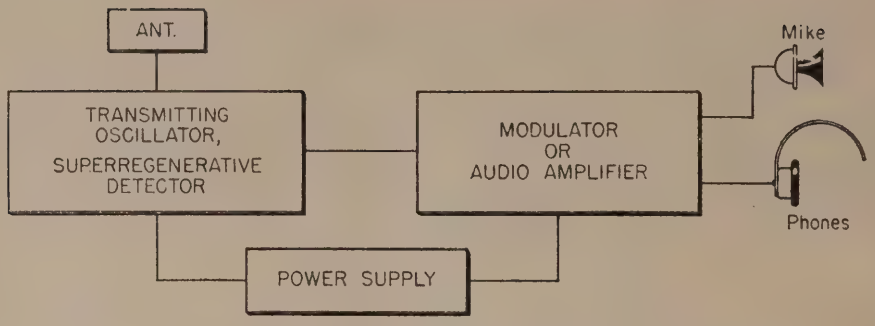

CRYSTAL-CONTROLLED UHF TRANSMITTER

FIG. 3

Although equipment of the transceiver type has been approved by the FCC for use in the citizens' band, very careful engineering is required to comply with the Class B regulations. This difficulty is due to several inherent limitations in the performance of modulated, self-excited oscillators and transceivers in general. These limitations may be listed as follows:—

(*a*) *Transmitter Instability.*—The inherent frequency stability of most self-excited oscillators in the UHF range is very poor. The frequency is affected by changes in applied voltage, capacity changes caused by thermal expansion of vacuum tube elements, changes in ambient temperature and humidity, capacity variations due to proximity effects, antenna loading variations, and mechanical vibration. Voltage fluctuations due to plate modulation alone may cause frequency modulation amounting to several hundred kilocycles. The combined result of such effects is to make it exceedingly difficult to design an oscillator at 465 mc. which will meet the prescribed tolerances in the hands of the public.

(*b*) *Receiver Radiation.*—The great simplicity of the




TRANSCEIVER BLOCK DIAGRAM
FIG. 4

transceiver results from the dual use of the tubes. However, when the transmitting tube is used as a superregenerative detector coupled directly to the antenna, a signal which is pulsed at the frequency of quenching is radiated. This signal is a potential source of interference to other citizens' radio stations and adjacent services. Receiver radiation may be prevented by the addition of an R.F. stage between the antenna and the "superregen" detector, but the presence of this stage complicates the function of transmit-receive switching considerably.

(*c*) *Transmit-receive Frequency Difference.*—Due to the change in operating voltage, there is a considerable difference between the frequency of transmission and reception in most transceivers. This discrepancy in frequency has the effect of causing two stations in communication to drift around the band unless the transmitter of each is retuned to a given frequency before every transmission.

Nevertheless, the transceiver presents a very inviting approach to the problem of simple and economical equipment for the Citizens' Radio Service, and the solution of its limitation is a challenge to equipment designers.

## PROPAGATION CHARACTERISTICS

Because the citizens' band allocation is in the UHF portion of the radio spectrum, communication is usually

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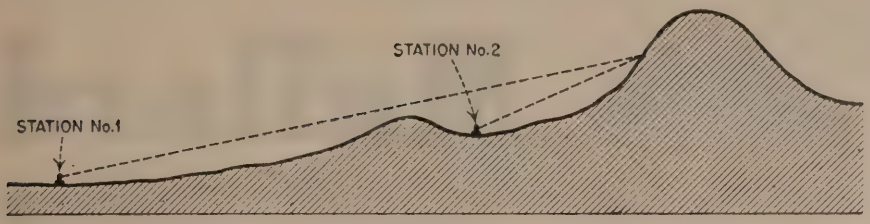


SHOWING UHF COMMUNICATION BY REFLECTED WAVES
FIG. 5

limited to virtual line-of-sight distances. Stations using a few watts input, as is characteristic of stations of the "man-portable" kind, are able to communicate for distances ranging from a few blocks in very populous city areas, to several miles in residential districts having fairly flat terrain. Over truly optical paths, such as might exist between stations operating at elevated locations, appreciable distances may be spanned, even with very low power. The present record for amateur communication in the 420–450 mc. band is 262 miles.

Waves at these frequencies are attenuated considerably by dense foliage. Antennae, therefore, should be above tree-top level wherever possible. Because of the portable applications of the service, vertical antenna polarization will be favoured for its omnidirectional properties.

There are also very pronounced "shadowing" effects behind hills, tall buildings, and other large obstructions at these frequencies. In many cases, however, reception at such sites may be made possible by indirect path propagation of the type illustrated in Fig. 5. By this means, radio waves reflected by other large obstacles may reach the receiver by indirect routes.

Citizens' stations using the high-performance equipment specified for the Class A licence, and the greater power permitted under these conditions, should enjoy considerably greater dependability of communication. The use of very stable transmitters will permit relatively


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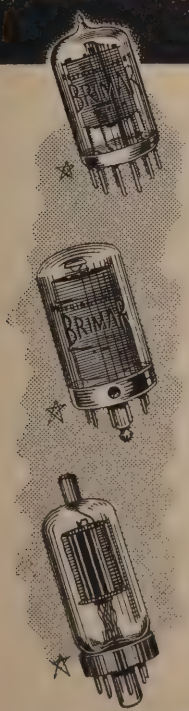

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| 1.4-volt Battery Types | 1T4 | 1R5 | 1T4 | 1U5 | 3V4 | — |
| 6.3-volt Loctal Types | 7H7 | 7S7 | 7H7 | 7K7 | 7C5 | 7Z4 |
| 6.3-volt Octal Types | 6K7GT | 6K8GT | 6K7GT | 6B8GT | 6V6GT | 5Y3GT |
| 6.3-volt All Glass Types | 6BA6 | 6BE6 | 6BA6 | 6AT6 | 6AM5 | 6X4 |

**Additional types in the above ranges together with other British Brimar made American replacement types, including 12-volt loctals are also available.**

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narrow-band, high-gain superheterodyne receivers to be employed. The resulting improvement in receiver sensitivity should enable this type of station to communicate over distances several times greater than those covered by Class B stations. High-gain directional antennae of the kind shown in Fig. 6 in the *Aerovox Research Worker* of August, 1949, may be employed by stations at fixed locations.

## COMMERCIAL ASPECTS

The Citizens' Radio Service represents a new field of endeavour for the manufacturer and radio serviceman. Since the licensing procedure for the service is based primarily upon the availability of commercially manufactured equipment, a large potential market exists for type-approved sets which can be economically produced. The high cost of satisfactory equipment for two-way radio-telephone communication is at present a major drawback in the expansion of this service.

In a similar manner, citizens' radio provides a lucrative field for the service-man who equips himself with a commercial radio-telephone licence so that he may legally engage in installation and maintenance of citizens' radio sets. As the service grows and gains in popularity, it should be possible for an enterprising technician to build up a large clientele of citizens' band licensees. Since the service-man will have to assume responsibility for the proper functioning of the equipment under his care it will be necessary for him to acquire some specialized test equipment, such as a precision UHF wavemeter, for this purpose.


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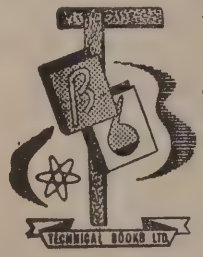


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## VALVE NEWS

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|---|---|---|---|
| 20AV | Vacuum | B8G | 45 |
| 20CG | Gas | B8G | 150 |
| 20CV | Vacuum | B8G | 25 |
| 55CG | Gas | Pee-wee | 125 (equiv. RCA927) |
| 56CG | Gas | UX | 150 (equiv. RCA918) |
| 90AV | Vacuum | B7G | 45 |
| 90CG | Gas | B7G | 125 |
| 90CV | Vacuum | B7G | 20 |

*Other cells, including end-on types, will be announced in due course*

### MULLARD MINIATURE (B7G) VALVES

**In the following table, Mullard miniature valves on the B7G base are listed, with the type numbers of their American equivalents**

**I—Directly Heated**

| *Mullard Type* | *Amer. Equiv.* | *Description* |
|---|---|---|
| DAF91 | 1S5 | Single diode pentode |
| DCC90 | 3A5 | R.F. double triode |
| DF91 | 1T4 | Variable-mu R.F. pentode |
| DF92 | — | R.F. pentode |
| DK91 | 1R5 | Heptode frequency changer |
| DL91 | 1S4 | Output pentode |
| DL92 | 3S4 | Output pentode |
| DL93 | 3A4 | A.F. or R.F. output pentode |
| DL94 | 3V4 | Output pentode |
| DL95 | 3Q4 | Output pentode |

**II—Indirectly Heated**

| | | |
|---|---|---|
| DA90 | 1A3 | R.F. diode |
| EAC91 | — | Diode triode |
| EB91 | 6AL5 | Double diode (sep. cathodes) |
| EC91 | — | Earthed grid triode |
| ECC91 | 6J6 | R.F. double triode |
| EF91 | — | R.F. pentode |
| EF92 | — | Variable-mu R.F. pentode |
| EL91 | — | Output pentode |
| EY91 | — | Half-wave rectifier |
| 2D21 | 2D21 | 100mA tetrode thyraton |

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# The New Zealand Electronics Institute (Inc.) Newsletter

## GENERAL NEWS

**Examinations:** Students are advised that due to unfortunate circumstances, it has been necessary to postpone the proposed examinations from March, 1950, to September, 1950. All students desirous of sitting the examinations should contact the General Secretary, P.O. Box 1368, Wellington, as soon as possible in order that the requisite forms may be completed.

**Membership Certificates:** These are at present in course of preparation and should be under issue very shortly.

**Christchurch Branch:** A general meeting of the Christchurch Branch was held on the 27th February, 1950, when the speaker for the evening was Dr. C. Ellyett, who gave a talk entitled "The New Science of Radioastronomy." Dr. Ellyett has just returned from three years spent as an I.C.I. Research Fellow of the University of Manchester. He was engaged on the investigation of meteors by radar methods at the geophysics research station maintained by the University. Now he is on the staff of Canterbury University College.

In his lecture Dr. Ellyett traced the development of devices for the tracking of meteors, from early visual aids to the complex radar-type equipment now being used. He mentioned co-relation between meteor activity and "Sporadic E" conditions, and drew attention to the assistance that could be given in optimum frequency calculations for radio communications, when the full connection between these conditions was determined.

The speaker concluded with an outline of future studies to be pursued, both overseas and in New Zealand. The meeting closed at 9.45 p.m. after a tribute and vote of thanks to the speaker had been led by Mr. Withers.

**Dunedin Branch:** A formal meeting of the Dunedin Branch was held on the 9th February, when several members attended to hear a lecture with demonstration of the Wallman cascode converter by Mr. W. L. Shiel.

Both the lecture and the demonstration were much appreciated. The cascode converter circuit due to Wallman has, among other factors, been instrumental in greatly improving the range over which radio communication is now possible in the shorter wave bands, owing to its greatly increased signal/noise ratio and very high stability.

At the conclusion of the lecture Mr. Shiel was accorded a hearty vote of thanks and the meeting then adjourned for supper which was most thoughtfully provided by Mrs. Shiel and was highly appreciated by all present.

The passing of a vote of thanks to Mrs. Shiel for her kindness brought the evening to a conclusion.

**Wellington Branch:** The monthly meeting of the Wellington Branch was held on the 7th February last, when formal business was transacted, there being no guest speaker for the evening.

The following matters received attention:—

**Library:** It was reported that the Library, which was established early last year, is slowly growing to a stage where it will be necessary to arrange for suitable accommodation in order that students may have the benefit of reference to the various technical publications received. Included in these publications are:—

Radio and Electronics
Philips' Technical Material
A.W.A. Radiotronics
G. R. Experimenter.

The Wellington Branch would appreciate from any member donations of text books not in use by the individual concerned, in order that others may have the benefit of obtaining the books for reference purposes. Any person desirous of donating such books should contact the District Secretary, Mr. McCormick, telephone 46-045—extension 918.

**Meeting Room:** The question of a meeting room came under discussion, and it was agreed to adhere to the present policy of holding meetings in the Y.M.C.A. rooms, Willis Street, but that efforts be made to obtain the use of the Public Library for the annual meeting to be held the first week in June.

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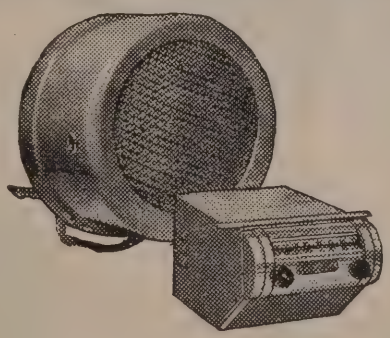

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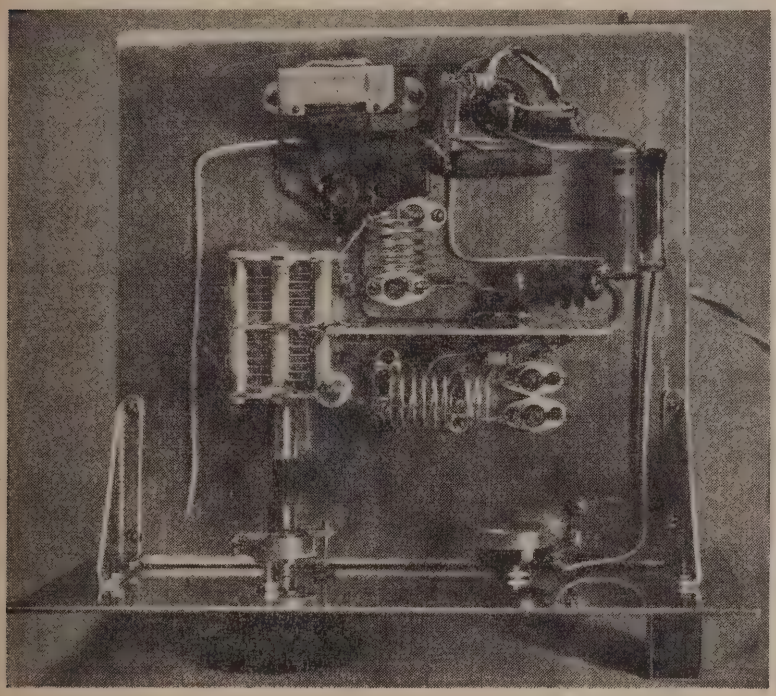
## PHILIPS EXPERIMENTER

(Continued from Page 25.)

as a regenerative detector, since the control of screen voltage gives such a smooth control of the regeneration. Similarly, the control of the screen voltage gives a very smooth control over the super-regenerative action, as was found when the prototype model of this set was constructed. The circuit appears to be identical with an ordinary regenerative detector, but without any control over regeneration. With ordinary valves, one would not expect that the grid leak and condenser, of 2 megs. and 15 $\mu\mu$f. respectively would make the circuit super-regenerate, but it must be remembered that we are dealing with a high-Gm valve, which will normally oscillate much



harder than an ordinary one. Thus, it will super-regenerate with smaller grid leak values than will an ordinary tube. The valve has a fixed screen voltage of approximately 60 volts. Most super-regen. sets have some control for the plate voltage, so that the best condition can be chosen for effective super-regeneration. In this set, however, such a control is not needed, mostly because we have a stage of amplification between the aerial and the detector. It is the effect of aerial loading on the ordinary set of this kind that makes it advisable to control the strength of oscillation, since the aerial coupling, as well as the plate voltage, helps to determine whether super-regeneration will take place. The R.F. stage acts as an isolator, and prevents the effect of the aerial loading from being felt by the detector. With this variable made constant, as it were, there is no reason why the best value of screen voltage cannot be found, and fixed, and this is what we have done here.

In order to achieve as much gain as possible, the detector is choke-capacity coupled to the audio amplifier stage. The choke can be the primary winding of a small audio transformer, and any old-fashioned component of this nature can be used. In our case, a new one was used and was found quite satisfactory. A 500 $\mu\mu$f. mica condenser is used as a by-pass condenser at the plate of the detector. It has to be fairly large, like this, because it has to by-pass not only R.F., but also the quench frequency, which is in the region of 25 kc/sec. It also helps to by-pass to earth some of the higher of the super-regenerative noise components, and make the inter-station hiss a trifle less troublesome, without affecting to any extent the quality of the audio.

### CONSTRUCTION

It is a fallacy that a simple set does not need as much trouble spent on its construction as a complex one, and the present set is no exception. Rigidity is the main requirement as far as the R.F. and detector stages are concerned, and the photograph gives some idea of how this has been obtained. The valves are mounted upside down, and as close to the coils as possible. The coils themselves are made of heavy tinned copper wire, and are mounted on midget stand-off insulators. A shield partition is used across the cocket of the R.F. stage, and this serves at the same time to shield the coils from each other. In addition, it will be noted that the coils are standing at right-angles to each other as an added precaution against coupling between them. The gang condenser is operated by a vernier dial, which is mounted on the panel, and coupled to the condenser shaft with a flexible coupler. The panel, it should be noted, is braced by brackets at the front corners of the chassis. With the metal construction and the flexible drive, neither mechanical instability nor hand capacity are at all in evidence.

A most important feature of the construction is the way in which the R.F. stage is wired up. When we say that it is necessary to return the bottom end of the coil *and the cathode resistor and by-pass condenser* to the wiping contact of the gang condenser, this is exactly what we mean. In other words, this is not only desirable, but absolutely essential, unless one wants to have the R.F. stage oscillating. The stage is a high-gain one, and if the by-pass condenser, for instance, is returned even a fraction of an inch from the wiper, the effect is the same as returning the cathode of the valve to a tap on the coil. In other words, cathode regeneration. If this is done, however, there will be little chance of oscillation, especially when the aerial is connected, damping the aerial coil somewhat.

Apart from these few words, there is little that can be said to help the intending builder, except to give details of a trick that can be made use of in aligning the coils.

It will have been noticed that the minimum capacity in the detector circuit is fixed, and the maximum capacity is fixed by the gang condenser. The first thing in aligning the set, is therefore to adjust the detector coil's inductance by spacing the turns correctly until the band is all on the dial. This is not difficult, as there is approximately

(Concluded on Page 48.)

## WIDE-BAND AMPLIFIER

(Continued from Page 8.)

recommended that each bank should be on separate wafers, spaced about an inch apart on the operating shaft. The resistors $R_1$ can then be hung between corresponding contacts on the two wafers—a form of construction which looks neat and also causes less congestion. Looks are not the only things here, either, because it is most undesirable to have stray capacities between the unused attenuators and the one that is in use. The Philips trimmers can also be supported on the contacts of one wafer, and short leads taken to the opposite one on the other wafer, placing the trimmers in parallel with the resistors $R_1$.

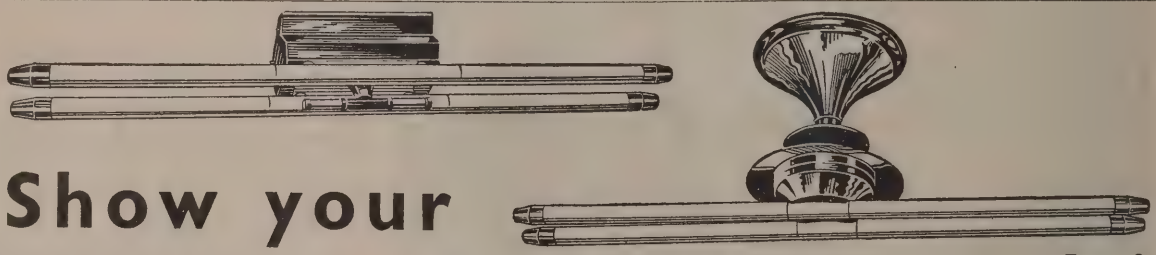
### ADJUSTMENT

There are two ways of adjusting the Philips trimmers. Either will give the same result—namely, that each attenuator section has a frequency response that is flat up to quite high radio frequencies. Both, however, require a certain amount of gear to perform. In an earlier article, the action of such compensated attenuators was described in detail, and so will not be repeated here, except to say that the correct adjustment is that which gives the capacity voltage divider the same degree of attenuation as the resistive one in parallel with it. Both methods of adjustment depend on the fact that if the capacitative and resistive portions do not attenuate by the same amount, the frequency response of the two in parallel will be anything but flat. For example, if $C_1$ is too large, there will be less high-frequency attenuation in the capacitative arm, and the response will rise at high frequencies. If $C_1$ is too small, things are the other way about, and the response falls off at high frequencies. Note that the low-frequency response does not enter into the picture, because $C_1$ is so small that at low frequencies it can justifiably be regarded as absent. And, since $C_2$ has its reactance arranged to be in proportion with the resistance of $R_2$, this condenser also has no appreciable effect at low frequencies.

The first method of adjustment uses an audio oscillator. This needs to have good waveform, and to be able to give constant output throughout its frequency range. One such as was described in these pages a few months ago would do admirably.

First of all, the oscillator is set to some low frequency, say, 200 c/sec., and the output control is turned so as to give two or three inches of deflection on the oscilloscope. No time-base is needed. This deflection is measured with a wooden ruler, and its length noted. Next, the oscillator is turned to, say, 20,000 c/sec., and, without altering the oscillator output voltage, the new deflection length is noted. The trimmer $C_1$ is then adjusted until the trace has the same length as the 200 c/sec. trace. We have now arranged for the response at 200 and 20,000 c/sec. to be the same. The response at all other frequencies must also be the same, since there is nothing in the circuit of the attenuator that can cause it to rise or fall once $C_1$ has been adjusted. The same procedure is now used to adjust the three other attenuators.

(Concluded on next page.)

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A difficulty in connection with the oscillator method is that, for the steps of higher attenuation, rather high input voltages are needed to get an easily measured trace on the tube. It is for this reason that the square-wave method is to be preferred. In this, the amplitude of the test signal does not matter, as it is the **shape** of the pattern on the screen that counts. For this method we need a time-base. The square-wave generator is set to give an output at, say, 400 c/sec., and the time-base is set to show about three complete cycles on the screen. If the input wave is really "square," and the response of the amplifier, etc., is wide enough, the pattern will have clean, square corners. If the response is down at high frequencies, two of the corners will be seen to be rounded. If the H.F. response is too great, these corners will exhibit a sharp peak of higher amplitude than the square wave itself. When $C_1$ is set correctly, the corners will be sharp, but no spikes will appear, either.

By adjusting the condenser, the transition from one pattern to the other can easily be seen and the right setting chosen. It is remarkable how sensitive this method is. Unfortunately, the scope of this article hardly allows us to describe a suitable square-wave generator for doing this job. It can be a very simple affair, and, in conjunction with an oscilloscope, can form a very convenient tool for the testing of audio amplifiers of other 'scope amplifiers as well as for other purposes. We therefore intend that a simple square-wave generator should be the subject of our next article on auxiliary 'scope equipment, and we are sure that readers will find the thing itself, and what it does, as exemplified by diagrams or photographs of actual patterns, very interesting indeed.

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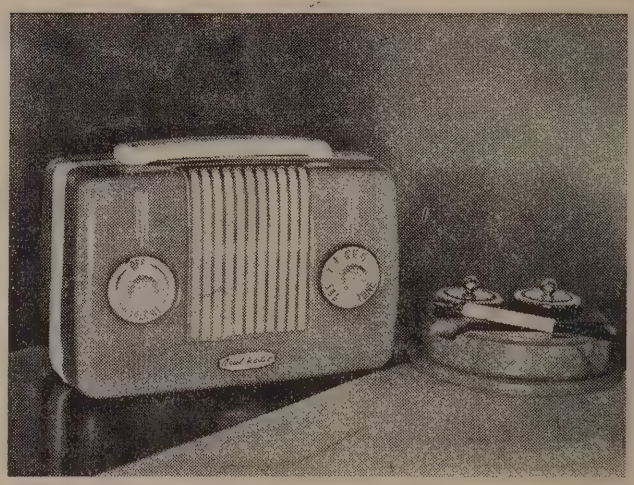

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# QUESTIONS AND ANSWERS

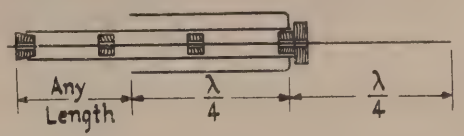
## TECHNICAL INFORMATION ON "VIOLET RAY" APPARATUS

A correspondent writes to us asking whether we can tell him where to get technical information on the old-fashioned "violet ray" apparatus. Even if it dates us, we must admit that this is one of the many subjects on which we know nothing whatever, never having been sufficiently interested even to find out just how this sort of thing works, though a few chords seem to strike vaguely in the back of the Editorial brain. However, we mention it in this column in the hope that some reader, better informed than we are, can pass on the information our correspondent requires.

## SOME REFLECTIONS ON 420 MC/SEC. AERIALS

"R.D.B.," Oamaru, writes requesting advice on suitable aerials for using the "Radio and Electronics" 420 mc/sec. transmitter-receiver at a fixed location. R.D.B. has sent a drawing showing the position and size of his house relative to a 300 feet high building close by, and short of erecting a fairly high mast, which he intends to do, the situation does not look very promising. His questions, and we hope the answers, will be of interest to all those who intend working the 420 mc/sec. band from a fixed location, and who, like R.D.B., are in difficulties about aerials to use. The questions are:—

"I am going to erect (*a*) an antenna (all steel) 40 ft. high and made from electrical conduit sitting on a porcelain base and guyed for rigidity, and (*b*) a 30-ft. wooden mast with a whip on the top. My questions is, will the steel mast have any effect on the transmitted signal, and, for (*b*) can you suggest a suitable method of tuning the aerial, allowing for a 40-foot lead-in wire to the shack. In addition, can you tell me how to tune the household antenna for use on 420 mc/sec."




We must say at the outset, and we hope without offending, that like other people we have talked to, our correspondent's ideas on V.H.F. aerials are somewhat conditioned by broadcast and medium frequency practice. In the first place, it is bad practice to try and use wires or masts of more or less random length for radiating or receiving V.H.F. signals. The position shown on the sketch for the 40 ft. steel mast indicates that its top is well clear of the offending building next door, but that at least three-quarters of its length is completely shielded by the building from the desired didection of transmission and reception. Now, if this mast were used as a radiator, most of the radiation would be absorbed by the building, particularly in the desired transmitting direction. Thus, our recommendation is not to use the mast as a radiator at all, but to use it to support a small vertical aerial, cut to the correct length for 420 mc/sec. Then, the feeders can be taken down beside the mast and off into the shack. This arrangement would be far more efficient than the one suggested by R.D.B. If desired, any of the directional arrays described in the amateur literature could be scaled down to the correct proportions for 420 mc/sec., and mounted on the top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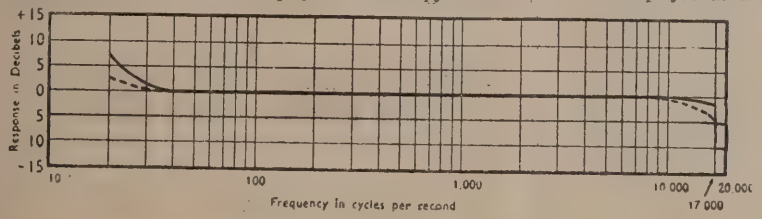


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of the mast. A very suitable aerial would be the skirted dipole that was described with the original article on the transmitter-receiver. A schematic of this aerial is reproduced here. It will be noted that the co-axial feeder line can be any length. If this were constructed of thin brass tube, as illustrated, it would not cost very much, and it could be lashed to the steel mast at intervals without any effect on its performance.

If the wooden mast is to be clear of the top of the interfering building, it, too could be used as a support for a co-axial feeder line with the same skirted dipole aerial at the top.

With regard to the idea of using (*a*) a long flat-topped household aerial for 420 mc/sec., and (*b*) a high vertical rod, as suggested in the letter, it can be said that the frequency is so high that aerials of this sort would be very inefficient, and also difficult, if not impossible to tune properly. Even if they could be tuned to frequency with any certainty, their radiation patterns would be quite unpredictable, and would show a multitude of small lobes and gaps. The sort of thing that could easly hapepn would be that the desired communication direction might be on one of the gaps where no radiation occurs, with the result that no communication would be obtained. For communication, in a specified direction, as our correspondent wishes to obtain, judging from his letter, there are several simple directional aerials that can be used to give increased power gain for the transmitter, and sensitivity for the receiver. For the frequency we are discussing, these aerial systems would be extremely small and light, so that building two, for Tx and Rx respectively, would be very little more trouble than building one. The main effort would be expended not in building or adjusting the aerials, but in providing a suitable piece of transmission line for each. Co-axial cable would be the best, but most expensive kind, and the easiest to instal, but there seems no reason why for the small power involved, one could not make up his own as suggested above.

## TROUBLE WITH TRANSMITTER COUPLING

"J.B." writes from Sydney that he is in trouble with his 807 transmitter, in that he cannot make it draw more than 50 ma. when coupled to a folded dipole, fed with 300-ohm transmission line. He states that the plate voltage is 550, the grid current 4 ma. through a grid resistor of 10,000 ohms, and that the tube also has fixed bios to the extent of 45 volts, and asks if we can tell him why he is unable to load the stage to a greater extent.

When this sort of behaviour is encountered, the first thing to suspect is the aerial itself. For if this is not cut to the correct length for the frequency in use, it is only to be expected that it will not load the transmitter properly when coupled to the final tank circuit. However, J.B.'s aerial is 32ft. 8in., which is the correct length for his frequency of 14.32 mc/sec., so we will have to look elsewhere for an explanation in his case. Another reason for an improperly loaded final is found when there is a mismatch between the feeders and the aerial. Then, even if the aerial is of the correct length, it will not always be possible, with any coupling system at the transmitter end, to load the final to its maximum plate current. In the case we are examining, this can be ruled out too, because the aerial is a folded dipole, which is an excellent match for 300-ohm transmission line. This leaves only one reason for the trouble. It is that the load impedance presented to the final amplifier valve is too high in value. The feeder is coupled to the final tank by means of an untuned coupling coil, coupled to the tuned tank circuit, and however tightly the coupling is done, no more than 50 ma. can be drawn by the amplifier. This means that even when the coil is closest to the tank coil, it does not load the latter heavily enough to enable the valve to produce its maximum power output. The cure is quite easy to apply, and consists simply in altering the L/C ratio of the tank circuit. As it is at present, its loaded Q is too high, which means that the tuned tank circuit has too much capacity and too little inductance. If our correspondent tries adding on a few turns and re-tuning the final, he will find that the maximum plate current will increase, and more power will be drawn from the valve, and coupled into the aerial. It will be remembered that when a tuned circuit is loaded with resistance (in this case the resistance is due to the 300-ohm input resistance of the feeders) the Q, and hence the impedance, is higher, the larger the tuning capacity. The building up of the coil can be taken just as far as necessary to enable the final to be fully loaded.

## HOW TO SHORTEN A TRANSMITTING AERIAL

The same correspondent also asks whether it is possible to put a loading coil at the centre of an aerial that cannot be made the full length for a half-wave dipole. For example, he would like to know how many turns, etc., are needed at the centre of a wire only 11 feet long to tune it to the 20m. band.

Although it would be quite possible to do what our correspondent suggests, it would be much better to use two loading coils at the ends of the wire, rather than a single one at the centre. The reason for this is that the part of the aerial which does the most radiating is the centre section, in which the current is greatest. For this reason, loading coils at the ends will give a much better radiation of the power fed to the aerial than the other

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scheme. An advantage of this method, too, is that the aerial can be fed in the centre in the ordinary way, by any of the recognized methods. Unfortunately, it is not possible to give an accurate estimate of the number of turns required for the loading coils, and these will have to be adjusted purely by trial and error until it is found that the antenna tunes to frequency. Another and simpler method than using loading coils is to make the flat top of the aerial as long as possible. Then, cut the wire to the official length for the frequency (approximately 32 feet in this case) and let the spare wire at the ends hang vertically downwards. Of course it will have to be braced so that it does not flap about, but this can easily be done by using strain insulators at the tops of the masts as pulleys, and straining the whole wire by means of ropes tied near the bottom of the masts. In this case there would be approximately 10½ feet of wire hanging down at each end. This sort of bent aerial will tune and load exactly as if it were all stretched out flat, and will be found almost as efficient as a radiator. Incidentally, when this trick is resorted to, one should remember not to make the flat top less than a third the length of the whole aerial, as any less than this becomes inefficient as a radiator, even if it tunes to frequency quite well.

## CLASS B AND CLASS $AB_2$ TRANSFORMER RATIOS

Another correspondent asks how Class B and Class $AB_2$ transformer ratios are calculated. Unfortunately this is rather a tall order, as it would take up a whole issue of *Radio and Electronics* to go into the subject at all satisfactorily. Indeed whole books have been written on the subject, which is a very difficult one, and far from cut and dried as far as the designer is concerned. By far the best plan is to stick to some well-known Class B tubes (or Class $AB_2$) and take the makers' recommendations as to the turns ratio of the input transformer. Practically all tubes suitable for this class of service have the recomemnded plate-to-plate load impedance specified in the data books, and the turns ratio of the modulation transformer or output transformer is calculated in the same way as for other push-pull amplifiers. That is to say, the turns ratio is the square root of the impedance ratio, whether step-up or step-down. That is to say, if the ratio of the two impedances to be matched is 4 to 1, then a transformer ratio of 2 to 1 will be needed. Deciding on the correct value of plate-to-plate load for amplifiers of these kinds is also a difficult business, tied up with the design of the amplifier as a whole, and part of the book that would be needed to answer the question in full.

## VALVES FOR A 20-METRE CONVERTER

Another Australian request is for advice on suitable valves for a high-performance converter for use on the 20-metre band. The I.F. is to be 1600 kc/sec., and the writer would like to use two stages of R.F. amplification, and modern miniature tubes.

There is a very wide choice of valves that will perform well at 20 metres and lower, and there seems to be no need these days to go past the current series of miniatures. A 6AK5 could be used for the first R.F. stage, if desired, and if one is available, and this could well be followed in the second stage by a 6BA6. The latter could also be used in the first stage, but it has not quite the low-noise performance of the 6AK5. As to the mixer, a triode would be ideal, from the point of view of low set noise, and there is no need to look further than the 6J6 for this purpose. As it is desired to use a separate oscillator, the 6J6 circuit described in a recent issue of *Radio and Electronics* would be very suitable. When we come to think of it the said issue is not so recent after all—in the April 1949 issue to be exact. The oscillator tube could be another 6J6, or a 6C4, or even a 6BE6 triode-connected. Our correspondent asks us to specify coil data for such a converter, but not having such information readily to hand, we must regretfully decline, as to work it all out would take a very long time, and would not be particularly accurate unless supported by experimental work.

# PUBLICATIONS RECEIVED

*Television Explained,* by W. E. Miller, M.A., M.Brit. I.R.E. Publishers: Iliffe and Sons, Ltd.

*Basic Television,* by Bernard Grob. Publishers: McGraw-Hill Book Co., Inc.

One of the interesting things about television as it is today is the fact that Britain and America use systems which are in basic essentials very similar, but which differ very considerably in detail. For example, where America uses horizontally polarized transmission, Britain has vertical polarization, and of the two main possibilities in utilizing the carried for transmitting the vision intelligence, one system uses positive modulation and the other negative. While essentially the same pulse system is used for synchronizing the received picture with that at the transmitter, one uses equalizing pulses, and the other does not. Again, the American system uses more lines per picture than the other, although the difference in practice, between the results from 525 lines and 441 does not in itself seem to be very great. Other differences occur, the main one being the use of frequency modulation in the American system for the sound, while the British system uses amplitude modulation. In spite of all these differences, it is still true that the two systems are

(Concluded on page 48.)

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# PUBLICATIONS RECEIVED

(Continued from Page 47.)

essentially identical, in that identical principles are used by both. It is not, perhaps, surprising that people who have seen both in action say that there is little to choose between them as far as quality of performance is concerned. Others say that the British television is able to produce a higher-quality pictures than the American, which on the face of it seems a little peculiar, especially in view of the rather wide difference in the numbers of scanning lines. However, one should realize that the number of lines, alone, is no criterion of the performance of television systems, and must be taken in conjunction with other features if a "paper" appraisal is to be made of the relatives merits of the two systems. For example, it has been shown that increasing the number of scanning lines *without* correspondingly increasing the horizontal resolution (by using a great video band-width), leads not to an improved picture, but a worse one.

All this is very interesting to those who have an interest in television, in spite of the fact that we do not seem to be destined to have our own for several years yet, but it is probable that a relatively small proportion of radio men in this country have any detailed knowledge of even the basic essentials of television. These two books, therefore are ideally suited to him who has a good working knowledge of "ordinary" radio circuits and techniques, and who wishes to broaden his general knowledge by acquiring the rudiments of a new and entertaining technique.

Both books are addressed to the same public, and are designed to fulfil the same purpose. The first is a small volume of little over a hundred pages, while the second is at first sight much more comprehensive in scope, and occupies over five hunderd pages. On closer inspection, however, it is seen that this difference is due to the fact that *Basic Television* is designed to give the serviceman something in the nature of a television course, which will equip him for what must be the somewhat arduous business of television servicing. *Television Explained,* on the other hand, makes no attempt to do more than explain the fundamentals, so that the reader will be in a position after reading it, to go on to a more advanced textbook. It is, moreover, much more in the nature of a popular exposition for interested, but not very technically minded people. For example, only seven pages are devoted to an explanation of that exceedingly complex thing, the composite video signal—*i.e.,* the signal which corresponds to the audio frequency signal in sound transmission. Not that anything is skimped, exactly, but the American volume goes into the matter in considerably greater detail, together with some numerical examples that are quite absent in the former.

Within their respective terms of reference, however, there is little doubt that both these books are excellent value. We would recommend those contemplating finding out something about television, and its circuitry ,to buy both, and read *Television Explained* first. This gives an excellent idea of fundamentals, and contains no mathematics or highly technical language. After this, it is suggested that the reader should tackle *Basic Television.* Here he will get a wealth of detail that is intentionally omitted from the first volume, and, if he wishes, circuits of complete receivers. The reader should be wary, though and should make sure that he has grasped the different meanings that are sometimes given to the same technical term on opposite sides of the Atlantic. If he does not, he is liable to be a little at sea until he has, sorted out such things as the British and American meaning of a "frame."

# PHILIPS Experimenter

(Continued from Page 41.)

1 mc/sec. to spare at each end of the dial when the coil is right. This done, the inductance of the aerial coil must be adjusted to suit, but it is not easy to do this with the set super-regenerating, because of the strong A.V.C. action of the detector. The thing to do, therefore, is to connect a 10k. resistor temporarily across screen and earth on the detector. This will pull it out of super-regeneration, and allow it to act as an ordinary grid-leak detector, without any A.V.C. action. Quite a strong signal is then needed for alignment, but this can easily be taken from a low-powered oscillator built for the purpose, or from the transmitter or exciter.

With the detector disabled in this way, the gang is set to maximum capacity, and $L_1$ is squeezed to give maximum signal. Then, with the gang at minimum, the Philips trimmer is adjusted for best results. This will probably affect the low-frequency end slightly, so that it will be advisable to go over the two adjustments several times until the R.F. stage peaks at both ends of the scale.

On the circuit diagram, a Faraday shield is shown between the aerial winding and the tuned circuit. This was not used on the original, but would be a worth-while addition, to prevent de-tuning by the aerial.

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